POWER

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New Year's Resolution

Let us swear our Resolution—*Julius Caesar*

THEY are not a week old yet, those New Year's Resolutions. How many have survived?

In spite of the popular disposition to ridicule the custom, it is a good idea, with the commencement of a new Season, to break off some bad habit or needless expense or time-consuming practice or to take up some worth-while pursuit.

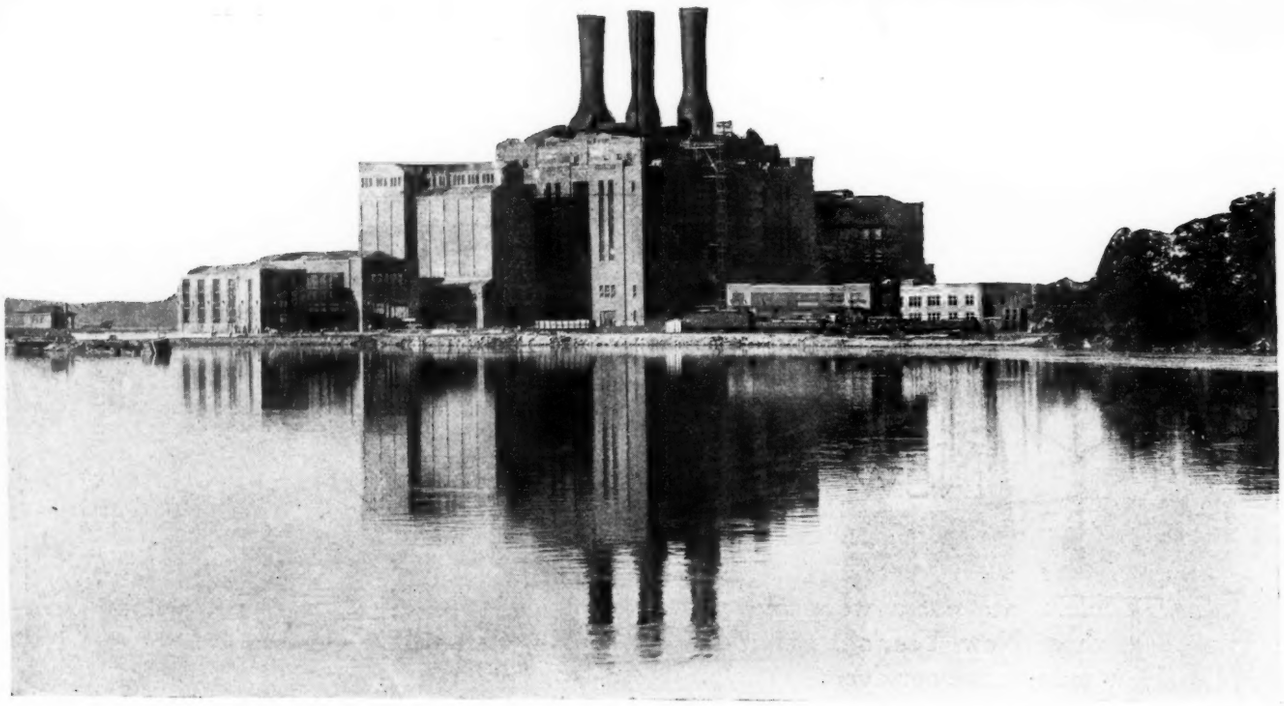
It is good to do any of these things at any time. The man who can break off a habit that he is finding harmful or who has the interest and application to take up something that he knows should be done for his own or somebody else's good just because he feels he ought, is on the road.

But most of us need to have a special urge, a place to take off from in a new start. The real fellow is, of course, the one who forgets a bad shot as soon as it is made, who charges off a failure or bucks through a run of hard luck and takes a fresh spurt as soon as the road is clear; but the ordinary man likes to have a lineup and a new deal.

And it is encouraging and inspiring to feel that here is a New Year, 8,760 clean white pages upon which we may write what we can, and which collectively will make our record for the year to come.

And of those yearly records our lives are made and by them our tale is told. At the end how much will we have got out of life? How much better off will anybody be for our having lived?

The record will be cleaner, perhaps longer and better, if those resolutions hold.



Trenton Channel plant, Detroit Edison Company, put into service this year

The Year's Progress in the Power Field

Many New High-Pressure Plants Go into Commission—Special Reheat Boilers, Air Preheaters and Water-Cooled Furnace Walls Factors of Special Interest—Stokers Approaching Powdered-Coal Efficiency

CONTINUING from 1923, business of manufacturers dealing in power-plant products was good for the first few months of the year. A great many plants were under construction, principally large central stations, but when this business had passed on and the products were in the hands of the user, there was a decided slackening in demand and this condition continued for the rest of the year.

Sporadic selling in the last month or two and a large number of inquiries giving promise of orders later, indicate a substantial revival in business for the new year. Conditions generally are sound in this country, the situation in Europe is much improved, stocks are light, and with the assurance of conservatism in the Government it would seem that a period of prosperity is at hand. In fact, the preliminaries are well under way.

The one thing that may deter good business and slow up the wheels of progress is a runaway market, resulting in inflation and a natural rise in prices. In steel, the barometer of industry, this would be disastrous, and in particular to those industries, such as the power-plant field, dealing primarily with this product.

That progress is being made in the power plant is revealed by statistics collected by the Geological Survey, showing that in 1923 the average large generating plant turned out a kilowatt-hour on 2.4 lb. of coal, as compared to 3.2 lb. in 1919. By the leaders in the field this figure has been reduced to 1.3 lb. for 1924, and some of the late plants just completed give promise of reducing the unit coal consumption to an even pound.

Formerly, two-thirds of the heat in the coal put into the steam going to the engine was considered good practice. Now refined methods of steam generation transfer from 80 to 85 per cent of the heat as a monthly average, and an over-all plant economy of 10 to 15 per cent, has been raised to 24, with good prospects of exceeding 30 per cent when full advantage is taken of stage bleeding, reheating and full utilization of the heat in the waste gases.

Factors that primarily have occupied the attention of the leaders in power-plant design in 1924 are boiler and turbine design to meet the higher pressures, reheating of the steam between stages, the use of air preheaters, stage bleeding, water-cooled furnace walls and the perfection of powdered-coal equipment.

Economizers are in active competition with the waste-heat air preheater, and in certain plants both are in use to insure maximum recovery of the heat in the flue gases. Evaporators have been made more accessible and deaërators simplified. Stokers are being built in great sizes and when installed in furnaces of proper volume protected by air or water cooling, and with the air for combustion preheated, are giving results close to those credited to powdered coal.

Systems of combustion control have come into greater prominence and a variety of instruments to give all forms of useful operating data have been developed. Full lines of high-pressure valves and fittings are now available and many other new things made essential by operation at higher levels and at increased ratings.

Interest in superpower and interconnection was revived during the year by a series of conferences called by Secretary Hoover in an endeavor to promote a higher degree of interconnection and also to obtain better economic use of the various power sources. To facilitate the work a series of maps were prepared in the offices of the Federal Power Commission with the idea of enabling all concerned to visualize the existing power situation and to gain an idea of the probable trends during the next fifteen years.

In the United States today there are about 6,000 separate power and lighting systems. Interconnection of many of these isolated systems over large geographical areas is needed to provide a great reservoir into which may be poured the output of the larger steam stations and water powers. As indicated by the studies made, some interconnection has taken place involving less than 10 per cent of the total number of systems. More progress is being made in the far West and in the Southeast, where power development has been mainly from water sources. Power lines from San Diego to Seattle will soon be connected throughout and in the South the superpower development extending from Alabama across to North Carolina is the most advanced. In the Northeastern States little has been done in interconnection. The existing interconnections are not such as to permit the transfer of any large quantities of power. It is probable that the real stimulus to interconnection in this area will come only with the development of large blocks of power on the St. Lawrence, Delaware and Susquehanna Rivers.

A thorough investigation of the power requirements in New England, made by a committee appointed by the Associated Industries of Massachusetts showed that 1,400,000 kw. would be required within the next ten years to meet increasing demands and that one-half the demand of the section is now met by industrial plants having use for process steam. Additional information on this section covering eleven states is contained in a report issued by the Northeastern Superpower Committee formed as the result of the conferences called by Secretary Hoover.

In the Southeastern States interchange of power between the principal systems in the territory has proved so successful that subcommittees on operation and engineering, with representatives from each company, have been appointed to secure still closer co-operation.

A further indication of the great interest taken in interconnection and systematic development of the power resources in different sections of the country is the "electric power survey" instigated by the National Electric Light Association. The first report dealing with the Great Lakes Division was made public during the year.

In Pennsylvania this general movement has been carried a step farther by Governor Pinchot in his Giant Power Survey. During the year an advisory board was appointed to pass on the final report of the survey before it is submitted to the state legislature, although the report will not be ready for another year or two.

In Indiana interconnection has been active. New plants have been built, and others of large size are in contemplation, transmission lines have been extended, communities linked into systems, and with interconnection between systems, superpower in this state soon will be a reality.

Boilers and Boiler Auxiliaries

Developments in Boilers, High Pressures, Status of Economizers and Air Preheaters, Superheaters, Stage Bleeding, and Heat Balance

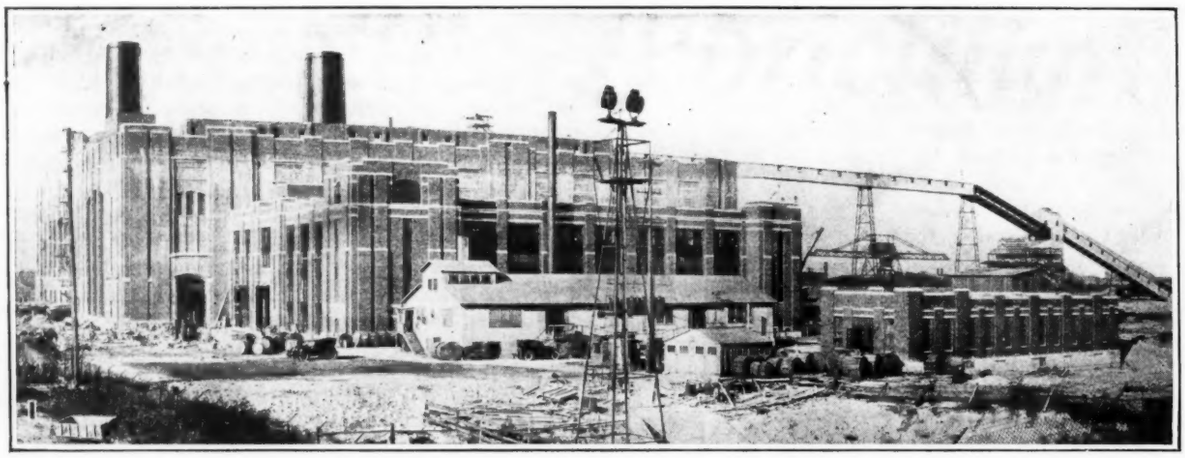
IN ALL branches of the steam-generating department of the power plant, there has been great activity during the year just closed. Higher pressures have called for boilers of modified design. To meet operation at higher ratings, furnace volumes in many cases have increased, and improved methods of protection, such as ventilation of the side walls or the use of water-cooled walls have been adopted. To improve economy the steam making surface is being arranged to better advantage, including maximum exposure to the radiant heat of the fire, tubes are smaller in diameter and superheaters are being located to give more uniform temperatures under varying load. Gas velocities have been increased, and to reduce the loss in draft a number of two-pass boilers have been installed and experiments with single-pass boilers of large proportions installed during the year indicate possibilities of reducing the draft loss through the boiler without a reduction in efficiency.

Sizes of boilers for the large central plant have not changed materially, the average ranging as before from 12,000 to 20,000 sq.ft. An exception is the initial installation at the new Cecil plant of the Allegheny County Steam Heating Co., consisting of one boiler containing 32,750 sq.ft. of heating surface including that in the water screens and water-tube walls. This boiler, designed for a working pressure of 190 lb., is the largest in the world, having some 2,000 sq.ft. more surface than the new boilers of the Cleveland Electric Illuminating Co., which previously held the record. Its great size is made evident from a furnace volume of 19,350 cu.ft. and a cross drum 34 ft. long and 60 in. in diameter.

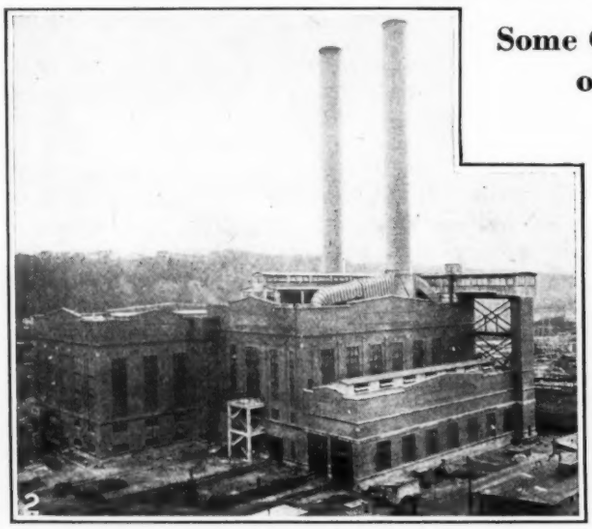
A new type of single-pass fire-tube waste-heat boiler has made its appearance. Utilizing about 80 per cent of the surface usually employed, it has shown exceptional economies, which are attributed to straight flow, high gas velocity in relatively small tubes, clean surfaces from scrubbing action of the gases and agitation causing high heat transfer.

The general trend toward higher steam pressures and temperatures in both central-station and industrial plants has continued, the former paving the way and the smaller industrial plant following along at a lower level commensurate with the load factor and the investment warranted for a specific case. Temporarily metals employed limit temperatures to 750 deg. F., but in pressures there is a wider latitude, authorities varying as to the range that commercially will prove most economical.

In the many papers presented at the World Power Conference the general consensus favored higher pres-



Some Central Stations Completed or Nearing Completion in 1924



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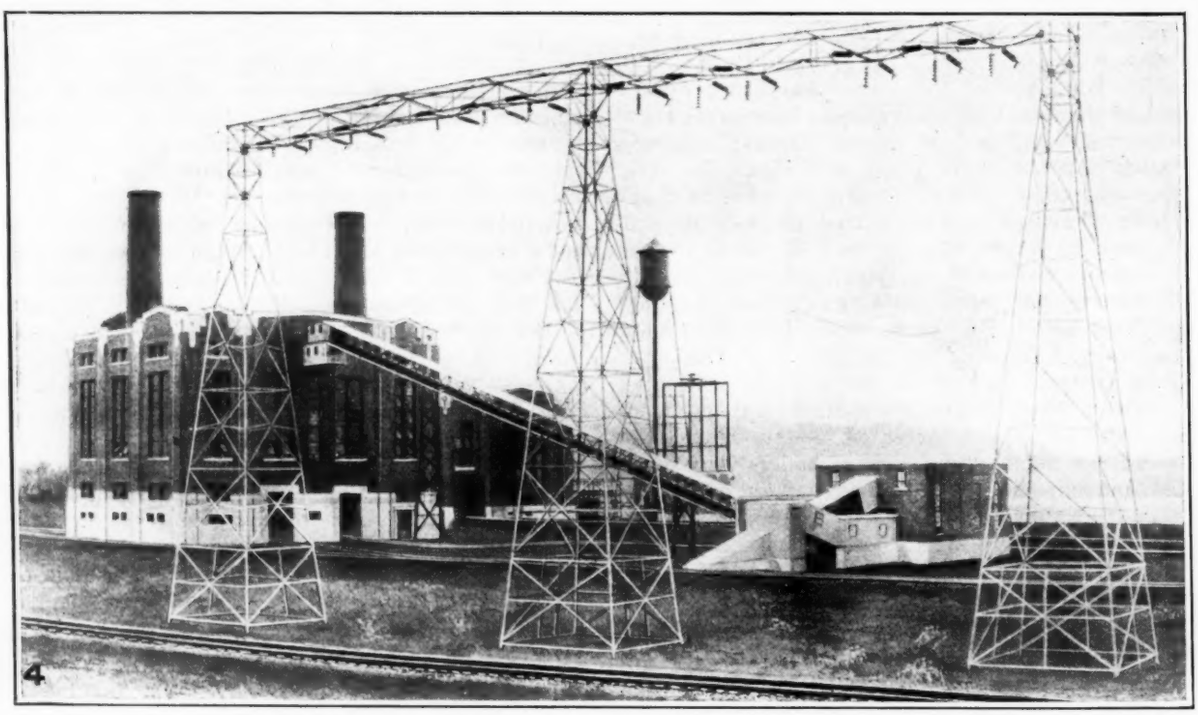

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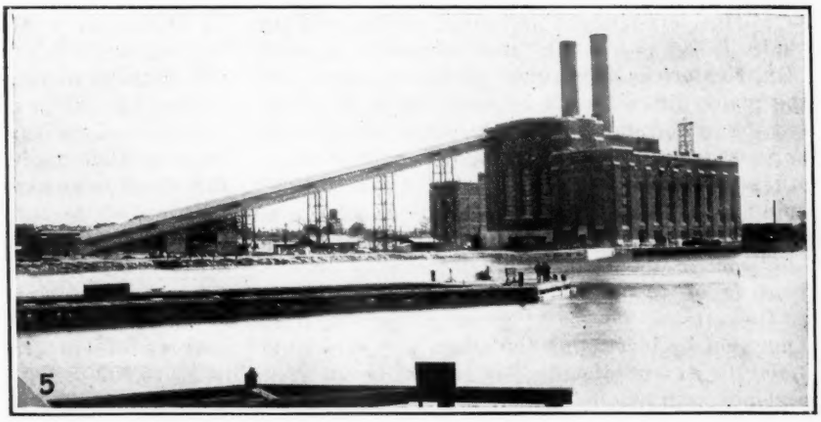


Fig. 1—Crawford Avenue plant, Commonwealth Edison Co., Chicago. Steam conditions, 550 lb., 750 deg. F. reheat after partial expansion in turbine

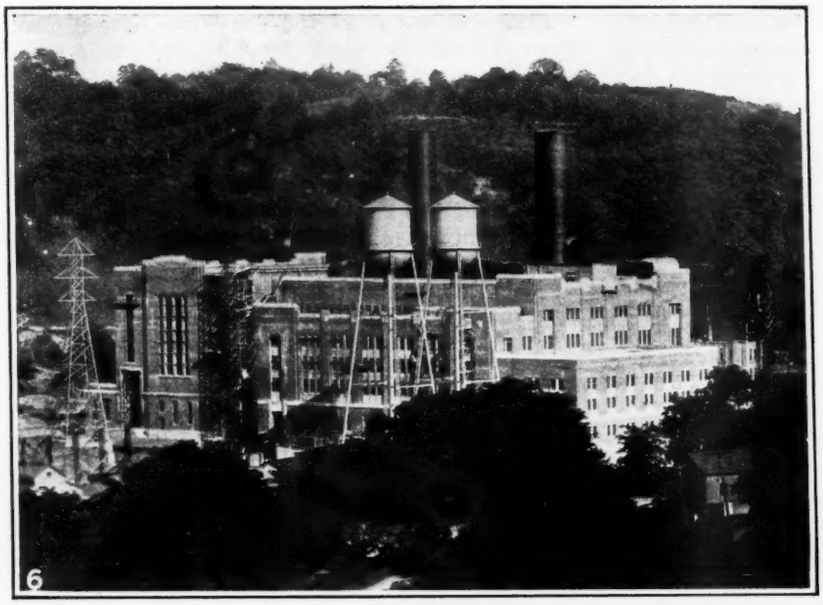


Fig. 5—Weymouth plant, Edison Illuminating Co., Boston. Steam conditions 375 lb. and 700 deg. F. Plant also contains one 1,200-lb. boiler and turbine exhausting into station header after reheating

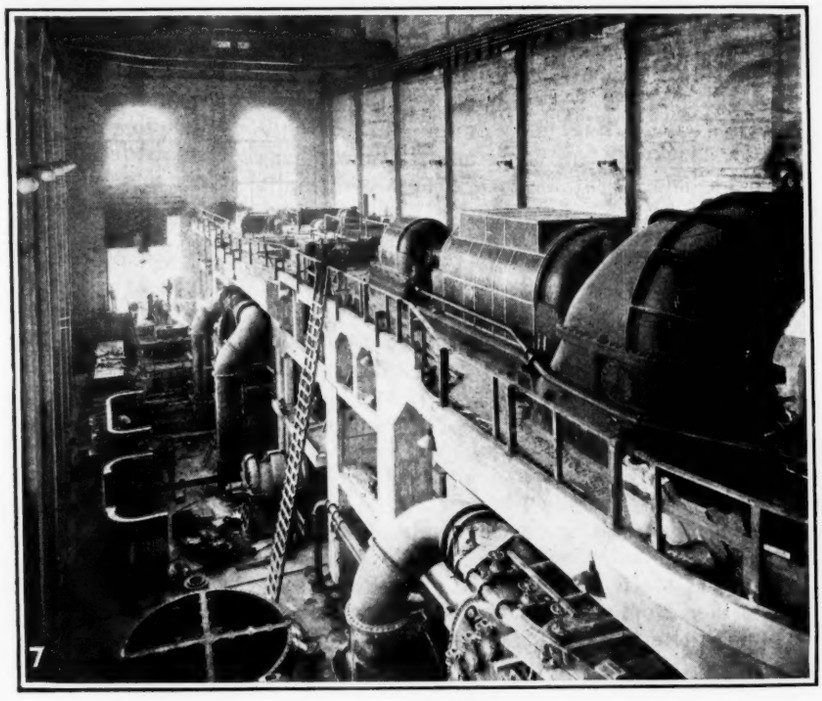
Fig. 6—Philo plant, Ohio Power Co. Steam conditions, 550 lb. and 750 deg. F., reheating after partial expansion in turbine

Fig. 7—Long Beach steam plant, Southern California Edison Co. One 35,000-kw. unit in operation, second unit about ready. Plant unit about ready

Fig. 2—High Bridge plant, Northern States Power Co., St. Paul. Steam conditions, 300 lb., 675 deg. F.

Fig. 3—Hales Bar steam plant, Tennessee Electric Power Co., built as a stand-by to a hydro-electric system, has an installed capacity of 50,000 kw. Steam conditions, 386 lb. and 725 deg. F.

Fig. 4—Grand Tower plant, Central Illinois Public Service Co. Steam conditions 400 lb. and 750 deg. F.



sures, with some diversity of opinion as to the limits it would be feasible to reach. For example, V. Nordstrom, of Sweden, considered steam pressures of 750 to 1,500 lb. per sq.in. to be within the range of practical possibility. Dr. Frederich Munzinger, of Berlin, after outlining the many difficulties to be anticipated, was confident that the power station of the future would operate at pressures ranging from 600 to 1,400 lb. and at steam temperatures from 750 to 800 deg. F. Such stations in his opinion would use the regenerative cycle, steam accumulators in the low-pressure range to make possible the use of smaller drums in the high-pressure boilers, resuperheating of the steam, pulverized fuel and air heaters. On a total cost basis a net saving of from 10 to 20 per cent by increasing the steam pressure from 220 to 1,400 lb. was predicted. Sir James Kemnal felt that experience with 500-lb. pressure had been sufficient to anticipate generation at 500 to 1,500 lb., superheated to 750 deg., or higher. Certain American engineers who have investigated the subject are less optimistic in that they can see no increase in the net commercial gain beyond 900 to 1,000 lb. Only the future will determine the accuracy or error in these predictions.

Heat Units per Kilowatt-Hour

At the present time pressures at the turbine throttle around 550 lb. and temperatures up to 750 deg. F., are considered reasonable, and experience with a 1,200-lb. boiler now being installed in the Weymouth station may lead to a gradual rise in pressures to perhaps 1,000 or 1,200 lb. It should be pointed out, however, that the gain in economy is slow with increase in pressure above 600 pounds.

A point that should not be overlooked is the fact that extra-high-pressure steam is particularly advantageous in the industrial plant using steam for process work as well as for power generation. It has been shown that the higher the back pressure the greater will be the saving, so that it will be well worth while for average industrial plants as well as the great central stations of the country to investigate thoroughly the possibilities of using steam at the higher pressures.

Quite a number of plants are practically complete or now building in which the steam will be generated at 600 lb. and 725 deg. F., with reheating at pressures around 100 lb. Generating units ranging in capacity from 35,000 to 60,000 kw. are being used. Comparisons have been made showing that with a 50,000-kw. unit operating at 350 lb., 725 deg. and 29 in. vacuum, a thermal efficiency of 29.54 per cent may be obtained; at 550 lb. this increases to 31.32 per cent and with reheating to 33.09 per cent. Taking into account boiler losses, this would mean the production of a kilowatt-hour on 13,000 to 14,000 B.t.u., or practically one pound of coal. This may be compared to 17,000 B.t.u., or 1.3 lb. of coal, which is representative of the best plants now in operation, and to 0.94 lb., or better, anticipated for the 1,200-lb. installation at Weymouth.

Boiler Designed for Reheating

One of the most interesting developments of the year is the special reheat boiler, such as is employed at the Crawford Avenue station in Chicago, the Philo station and the Miami Fort station now under construction near Cincinnati. In the plant first named there are five boilers per unit of 50,000- and 60,000-kw. capacity. In each case the boiler nearest the turbine is equipped with a reheater, or interstage superheater, containing approximately 14,000 sq.ft. of surface, which is mounted on top of a boiler of 6,000 sq.ft., as compared to 16,615 sq.ft. for each of the four normal boilers serving a unit. The boiler under the reheater will generate 65 to 70 per cent as much steam as a normal boiler, but its primary function is to reduce the temperature of the furnace gases sufficiently to obviate the burning that might take place if tubes containing only dry steam were exposed to furnace temperatures. Other features of the boiler are a contra-flow economizer containing over 11,000 sq.ft. in 2-in. tubes and a forced-draft chain grate 20 ft. 6 in. long and 24 ft. wide. After making due allowances for stand-by losses, the loss of plant efficiency from irregularities of load and the burning of low-grade coal such as is available in Illinois, 15,000 B.t.u. per kilowatt-hour appears to be a conservative figure expressing the average results obtainable from the foregoing plant.

From the design of the Crawford Avenue plant and others using the same pressure, it would seem that reheating of the steam is favored for pressures higher than 500 lb. So far the plan followed is to pipe the steam back to the boiler room, to one large reheater per turbine located in one of the boilers serving the unit, as previously described. Setting aside one boiler for the purpose has been necessary, as otherwise control of the amount of reheat would be difficult if not impossible.

Objections to Reheating

There are some practical objections to reheating, among which are the cost, the complication and the storage of energy in the reheating system, which usually makes it necessary to have a special valve on the low-pressure half of the turbine to prevent runaway. Certain authorities do not favor this method of reheating, suggesting the use of live steam instead with suitable heaters at the turbine. This permits only a relatively low temperature of reheat. Another suggestion is that separately fired superheaters designed for coal, gas or oil be used, and others propose the use of special fluids, such as mercury vapor. It seems probable that some of these methods, particularly the separately fired superheater, will come into more general adoption as more stations are built for high pressures, although work now being done on the direct separation of moisture from the steam as it is formed in the turbine, may make it feasible to do away entirely with reheating.

Tests on the Benson Steam Generator

It is of interest to note that publicity has been given to tests conducted on the Benson generator at Rugby, England, the object being to demonstrate that steam could be generated at 3,200 lb. without ebullition and to demonstrate the efficiency of the plant as well as furnishing data for the design of larger commercial units. According to the builder's report, the generator only was in operation and discharged directly to a surface condenser against a back-pressure valve which maintained a pressure in the superheater elements of 1,500 lb. The final results in a six-hour test were that a pressure of 3,250 lb. was maintained in the generator heating elements at a temperature of 725 deg. F. The fluid, on being throttled to 1,500-lb. in the superheater, reduced the temperature to 620 deg., and the superheater elements raised the temperature at 1,500 lb. to 910 deg. F. In spite of the designer's favorable report

of this test, made early in the year, no attempts at commercial utilization of Doctor Benson's patents have yet been announced.

While on the subject mention should be made of the combined boiler, superheater, economizer and air heater of the Stol Turbine Co., Finspong, Sweden. The entire equipment is standard, the boiler being made in all the usual sizes and for pressures up to 800 lb. per sq.in. In Germany the six-drum Borsig water-tube boiler, designed for a pressure of 1,400 lb. and a temperature of 788 deg. F., is of interest.

Effects of High Pressures on Boiler Accessories

That higher pressures generally have effected boiler accessories was in evidence at the recent Power Show in New York City. Valves of all kinds for the higher pressures now in use and for temperatures from 700 to 1,200 deg. were featured by the particularly heavy construction and the use generally of monel metal for parts subjected to severe service. The trend was reflected in high-pressure traps, water columns of forged steel, pumps of high speed that would function efficiently against the higher heads, feed-water regulators of improved design, excess-pressure pump governors in preference to the constant-pressure type, flat gage glasses instead of tubular gages and meters in great variety to register the higher pressures and temperatures and give the complex data required for the control and operation of the newer plants, new types of furnace-wall construction, improved refractories and a host of other things, all indicative of operation at a higher level and at increased ratings.

In safety valves, designers had the problem of maintaining proper valve action and capacity in addition to securing the proper strength of parts. Apparently the new requirements have been met, one manufacturer in particular having designed three valves covering a range of pressures from 400 to 1,500 lb.

Opinion Divided on Superheater's Location

In superheater practice no radical changes in fundamental designs have been reported. The two distinct schools continue, one favoring the convection superheater, placed above the tubes, or in the interdeck location when it is desired to secure higher temperatures with limited surface, or between the tubes near the fire, where the elements are protected from overheating by the surrounding cooler surfaces of the water tubes. The other faction gives preference to the radiant type located either in the rear or front walls, and when uniform temperatures under varying conditions of load are particularly desirable, a combination is made of radiant and convection types, as the opposing characteristics of the two units tend to maintain uniform superheat.

Steel-tube economizers of the individual-unit counterflow type are used to a much greater extent than formerly, notwithstanding the lower price of coal, which lessens the benefit, the decided trend to stage bleeding and air heating, and the necessity of purchasing deaërators to eliminate the oxygen in the system and prevent corrosion. The last-named difficulty has been relieved by the development of new closed feed-water systems, so that the deaërator arrangement may be greatly simplified or the water freed of oxygen in the condensers. With the reduced oxygen content it is often possible to change the plant heater into a deactivator delivering practically oxygen-free water.

As pointed out by one of the builders, stage bleeding shows a gain in the station operation as a whole up to a pressure corresponding approximately to the point of saturation in the adiabatic expansion in the turbine. This means that the feed water will be delivered to the boiler room at a temperature 180 to 200 deg. lower than that of the water in the boiler, thus giving the economizer an opportunity to show considerable saving. To obtain the full gain, the size and cost of the economizer would be excessive considering the present price of fuel, but by increasing the heat transfer at the expense of draft loss, a relatively small amount of heating surface will suffice. It is explained that one inch of draft may be obtained from the expenditure of heat represented by two degrees rise in the boiler-feed water, and when it is appreciated that fans suitable for continuous operation with 5 or 6 in. draft suction are now obtainable, there should be no hesitation in using economizers for raising the feed-water temperature to practically that of the boiler water and reducing accordingly the steam-making surface. This is suggested as the economizer surface is superior to boiler surface in capacity to absorb heat, owing to the counterflow of the water and gas, the forced circulation of the water and the better arrangement for gas contact.

Much Attention Given to Air Preheaters

During the year much attention has been given to air preheaters. The subject is not new in Europe, but the economies obtainable by preheating the air for combustion did not appear particularly attractive in this country until the rise in coal prices emphasized the gain. On the basis of their source of heat, air heaters may be divided into two general classes, namely, those in which the heat is transferred from the flue gases to the combustion air and those in which steam bled from the main turbine is used to heat the incoming air. Of the latter there is one in service at the Saginaw River plant of the Consumers Power Co. It is of cellular copper construction in three stages. Air from the forced-draft fan is raised from 80 to 300 deg. F.

Numerous flue-gas air preheaters, either of the tube or plate type, are in service, and results more favorable than theoretical calculations would indicate are being obtained, owing to other advantages besides returning a certain number of B.t.u. to the cycle. Those advantages are the more rapid combustion of the fuel, usually accompanied by reductions in excess air, in the carbon rejected with the ash, and in the length of the flame. In addition the efficiency of heat transfer is improved from the higher furnace temperature and the greater absorption of radiant heat. It is probable that the advantages will be more pronounced in the burning of low-grade fuels high in ash and moisture, when the furnace temperatures will not be excessive even with highly preheated air.

As recently pointed out in these columns, preheaters represent from one-half to twice the boiler-heating surface. At present they are limited in the temperature of the preheated air to about 450 deg. F., and to avoid excessive clinkering with certain coals, temperatures as low as 250 deg. may be desirable. From numerous tests under way it has been found that recovery of heat from the stack gases raises the boiler efficiency from 4 to 10 per cent. It would look as though air preheating had been established, but final judgment must be withheld until time enough has elapsed for the

operating and maintenance troubles to develop and for more complete returns from plants differing in design and using a wide variety of fuels.

Bleeder feed-water heating is now established as standard practice for new central stations; the only question is as to the number of bleeding points and their location. In the more recent plants, bleeding from two, three or four levels is common, the average probably being three bleeding points, with use of steam from the highest extraction for the evaporators. Bleeder heaters can be made safe and reliable under severe operating conditions, a case in point being the new Hudson Avenue station where heaters will stand full boiler pressure on the water side. They are simple and reliable, the only complication to the system being the additional piping. Stage bleeding in conjunction with electric auxiliary drive offers opportunity for higher efficiency, with a maximum of flexibility, at a cost probably lower than with any other form of auxiliary drive.

Feed Water and Its Treatment

The year's improvement in evaporators is noted in the report of the Power Show appearing in the Dec. 9 issue. Mention is made of an improved form of "Bentube" evaporator of sectional construction, in which each vertical row of bent tubes is removable easily for inspection. The apparatus can be operated either as a film or as a submerged-type evaporator. Another new evaporator that can be operated either way has coils of elliptical section for flexibility and a vertical shell that can be removed without disturbing the piping. These provisions facilitate cleaning, and in this connection it may be of interest to state that it is becoming common practice in large stations using bad makeup water to treat the water chemically before sending it to the evaporators.

In the field of feed-water treatment perhaps the most notable development of the year was the publication of the results obtained in the research work conducted jointly for three years by the Bureau of Mines and the Hagan Corporation. One of the conclusions from the research work was that chemical treatment of the feed should be controlled to maintain a certain constant sulphate concentration in the boiler. The system developed involves chemical treatment of the water in a manner determined by the boiler pressure and the concentration of sulphates in the boiler. It also involves the continuous recirculation of part of the boiler water through a special filter or deconcentrator.

Along with multistage bleeding from the main unit, the general trend has been toward electric-driven auxiliaries and, to supply the auxiliary power, the use of a house alternator driven by the economical main unit, with perhaps a small steam-driven unit for starting. In many plants dual drives for the essential auxiliaries are employed, one steam and the other electric, or two motors driven from different sources. For boiler-feed pumps, the steam drive is generally retained. Although relieved of its primary function, the house turbine in certain cases is used as a stand-by source of power, as a rule floating on the line to supply those auxiliaries that would be required to maintain station service in case of interruption to the main supply. With a number of units in the station and outside sources of power available, such reserve may be eliminated.

An interesting variation is to be found at the new Trenton Channel plant of the Detroit Edison Co., in which auxiliary power is furnished by steam-turbine-driven direct-current generators, by steam turbo-alternators and by a connection from the nearest substation of the company similar to that which would be made for any large customer. The house turbines are bled for station heating. The plant is operated on the regenerative cycle, heating the feed water by steam bled from three stages of the main units followed by economizers, with evaporators for 1¼ per cent makeup as a part of the main-turbine steam-extraction system.

In the first section of the Toronto station of the Ohio River Edison Co., now nearing completion near Steubenville, Ohio, the heat-balance system also has some novel features. For each main unit of 33,000-kw. capacity there is a 1,500-kw. house turbine which provides power for all major auxiliaries and is bled at the constant pressures of 196 lb. abs., and 52 lb. The turbine exhausts at 18 lb. By interlacing these bleed points with two on the main unit, together with a third point for the evaporators, the feed temperature is automatically maintained constant at 378 deg., no matter what the load, while the house turbine generates just the power required for the auxiliaries. The plant efficiency is practically the same as if all the auxiliary drive were furnished by the main unit, and at the same time the auxiliary service is independent of any outside or main-unit disturbance.

Centralized Systems of Combustion Control

As the year closed it found centralized systems of combustion control for boilers attracting an unprecedented amount of attention. Few large plants are being projected in which such systems are not considered, and a number of the most modern plants have installed or are installing such systems. Boilers with an aggregate heating surface of approximately 2,000,000 sq.ft. are controlled by such systems or the systems have been contracted for. Both mechanical and electrical and mechanical-electrical systems are being built and operated successfully. Just what the final outcome will be it is too early to predict. But the most gratifying feature is that the control of the combustion process in the power plant is beginning to receive the attention that it merits. If the past twelve months is any indication, the future for this class of business is exceptionally promising.

Driving boiler- and turbine-room auxiliaries by water turbines is the innovation introduced in the new Fairmont pumping station and heating plant in Cleveland. The water turbines are built from standard pump casings fitted with suitably designed propellers. On shop tests it was found that the efficiency for a given set of conditions was equal to or better than the corresponding pump efficiency. The turbines can draw water from three different sources, being supplied primarily with raw water under a head of 100 ft. and discharging against a head of 20 ft. The condensate pumps are driven by these water turbines, and owing to the extreme simplicity, reliability and excellent economy, this type of drive was used also for the four underfeed stokers serving 10,000-sq.ft. boilers, two of the oil pumps for the central oiling system and one boiler-feed pump. It is of interest to note that even if the steam pressure in the plant went so low that no steam prime movers could operate, the boilers could be fed from the hydraulic turbine boiler-feed pump and the stokers could be driven by the hydraulic-turbine drives.

Fuels and Combustion

Coal, Oil and Other Fuels, the Advance in Furnace Design, Development in the Stoker Field and in Powdered Fuel and the Improvement in Combustion Control

DURING the year an unusual amount of study has been given to the problems of coal, as the industry has been passing through a depression, notwithstanding that there have been only four years in the history of the country when more bituminous coal has been produced. This is explained by the fact that the non-union mines, principally of West Virginia and Kentucky, have been unusually productive, while the production in union fields has ranged from 25 to 45 per cent of normal, meaning the closing down of uneconomical mines, the merger of others and two- or three-day weeks in those able to keep in operation. Coupled with this is the lowest spot price for coal since 1916, notwithstanding the numerous wage increases since that time. Moreover, as a result of more careful mining methods the coal shipped has, in general, been cleaner.

For the eleven months up to Dec. 1 the total production of bituminous was 423 million tons as compared to 504 for 1923, 376 for 1922, the strike year, 383 for 1921, 515 for 1920, 429 for 1919 and 539 for 1918, all for the first eleven months. At the present rate of production the total tonnage for 1924 should approximate 460 million tons, which may be compared to the past seven-year average, exclusive of the strike year of 1922, of 520 million tons.

In the foregoing comparison no account is taken of the natural growth that is to be expected in any industry, so that the drop in tonnage for the year is really more than the figures indicate. Although the coal industry is not overburdened with data, enough are available to indicate that the state of the industry is not alone responsible for the decrease in the volume of consumption. Better utilization of coal in the power plants of the country and by industry in general, the increasing use of water power, the greater use of low-grade anthracite, and the greater use of fuel oil under boilers and in oil engines, both in marine and stationary practice, have cut heavily into the coal consumption of this country.

Elimination of Waste in Coal and Oil Industry

During the late months of the year it became evident that the bituminous coal industry is taking cognizance as never before of fuel-oil competition. The Board of Directors of the National Coal Association has authorized a program of research to find ways and means of giving coal the same convenience, cleanliness and efficiency as oil now affords, and as a means toward the same end the suggestion has been made that the two industries join hands in an effort to eliminate the wastes in both industries caused by overproduction and competition.

When the available supplies of coal and petroleum in the United States are considered, it will be apparent that this condition cannot last. Fuel oil cannot compete with coal for the generation of steam in land plants, except in certain localities when overproduction gluts the oil markets or when strike conditions upset coal production. Figures from the United States Geological Survey show that the total oil production of the world in the 66 years since 1857 up to 1924 has been 11¼ billion barrels, of which the United States furnished about 63 per cent. The estimated reserves of the world, according to Dr. J. D. Sears of the Survey, are approximately 42 billion barrels, of which this country is estimated to have 7 billions. In coal we have left about 1,510 billion tons of bituminous, having used less than one per cent of the original deposits; approximately 17 billion tons of anthracite after using 15 per cent of the original supply, and over 2,000 billion tons of lignite, making a grand total of 3,527 billion tons. On a heat-unit basis the ratio of available coal to oil in this country is about 1,680 to 1, and when the method of producing oil is considered, the necessity of pumping when a well has once been opened and the expense of storage in large quantities, the difference between the two reserves is magnified. New pools, of course, will be discovered in this and other countries, but it is quite evident that the short periods when oil has the advantage will become less and less frequent and of shorter duration.

Crude-Oil Consumption

According to estimates of the United States Geological Survey the consumption of crude oil in this country in 1924 will be about 803,000,000 bbl. The domestic output is placed at 720,000,000 bbl. and the imports at about 90,000,000 bbl., giving a total of 810,000,000 bbl. It is thus probable that the consumption plus exports will be slightly less than production, and the total stocks of Jan. 1, 1924, amounting to 465,000,000 bbl., increased to some extent. This excessive production, although about 12,000,000 bbl. less than in 1923, has thrown the industry into a most unsatisfactory condition. The low price of crude has stimulated its use in plants where it would not be justified under ordinary conditions. This trend, coupled with the pitiful waste under the present competitive methods of production and inefficient use, will soon deplete our entire supply. To relieve the economic distress now existing, there is need of regulation of the industry to control output in accordance with legitimate demand. This very subject is now being agitated. Co-operation among producers, pooling of interests, elimination of excessive drilling of wells are some of the remedies now being suggested, and it is evident that some such action must take place before the oil industry will be on a stable and profitable basis. It is pertinent to state that, although we produce 72 per cent of the world's oil, only 18 per cent of the world's reserves are controlled by this country. The demand for oil and its distillates has been increasing at an alarming rate, and from present indications the upward cycle will continue.

Production of anthracite last year was nearly normal, the total tonnage up to Dec. 1 being 82,800,000, as compared to 86,115,000 tons in 1923 for the same period. There have been a few local strikes in the

field, one affecting 12,000 men, but no general strikes to interfere seriously with production.

From the consumer's point of view an interesting development has been the perfection of furnace design for the better burning of low-grade anthracite. The old-time single ignition arch has been supplemented by a second arch at the rear of the grate, with a restricted passage between the two for the better mixing of the gases. The experimental work proceeded to the extent of trying three arches with somewhat better results, but with trouble from slagging. With the two-arch furnace outlined, excellent results were obtained with low-grade fuel with 30 per cent ash and of which 60 per cent would pass through a $\frac{3}{32}$-in. round-mesh screen. Ratings of 300 per cent were obtained, as compared to a limit of 190 per cent for the single-arch furnace.

Lignite is attracting more or less attention in this country and Canada. It is being used locally to a considerable extent. In recent studies of the most economical equipment for burning North Dakota lignite, containing 33 per cent moisture and 6,800 B.t.u. per pound, it has been pointed out that better engineering practice and methods of operation would do much to improve present results. Rocking grates showed up better than stationary grates, but increased the combustible loss in the ash. Best efficiency at present is being obtained from traveling grates of the non-sifting type equipped with ignition arches, the combined boiler and furnace efficiency for the year averaging 68 to 70 per cent. A study of the application of pulverizing indicated that with the unit system and waste-heat driers, the cost of producing steam would be 30 per cent less than with the ordinary hand-fired furnace and would equal results obtained with the chain grate.

Carbonization of Coal[1]

In high-temperature byproduct coke-oven practice the principal developments have been in the extension of the chamber method of carbonization for gas making in an attempt to make better domestic coke.

The development of the Koppers-Becker oven with crossover flues offers new possibilities in uniformity of heating and shortening of coking time.

In Germany the Collin oven[2] heats alternately from the top and bottom (instead of entirely from the bottom) in an endeavor to secure more uniform heating. It utilizes no vitrified refractory roof, employing only stamped fireclay pressed in. Thus it is said that repairs may be made without disturbing the superstructure.

Two new schemes for dry cooling of coke are mentioned in this same article,[3] one designed by Sulzer for gas-retort installations, and one by Collin for their coke ovens.

The Sulzer device cools with air (recirculated) with some combustion of coke, the heat being absorbed in waste-heat boilers. There is an installation at the Rotterdam gas works.

The Collin device consists of a closed chamber located under the discharge floor with capacity for cooling the coke from three ovens. The cooling is done by circulating flue gas, and the heat is absorbed in waste-heat boilers.

Perhaps the outstanding development in low-temperature carbonization has been the commercial-scale experiment of the Caracristi-Piron method installed at the Walkerville, Ontario, plant of the Ford Motor Co., which has not been installed long enough to permit conclusive results to be published. Another interesting American commercial-scale low-temperature carbonization project has been the Carbocite process of "Thermodizing" by which the raw coal is first oxidized, driving off the free moisture in an attempt to render the coal non-sticking for subsequent carbonization in rotary retorts.

In the foregoing connection mention should be made of a special retort patented recently by C. M. Garland, of Chicago, and described in these columns during the year. In the equipment the coal is coked evenly and continuously by superheated steam at one pound pressure generated from the volatile and residue of the coking process. It is of interest to state that the cost of treating coal containing 5 per cent moisture is estimated at 80c. per ton, including fixed charges.

Numerous other experiments have been carried on, both at home and abroad, none of them having at this date conclusively proved itself economically and commercially practicable at present prices of oils, tars and byproducts.

The Canadian Department of Mines announced that Canadian lignite had been carbonized by them in the Hood-Odell carbonizer at a price of $4 per ton of char, including all charges.

Powdered Coal Makes Large Gains

Although there have been no radical developments in the pulverized-coal field during the year, considerable advance and improvement have been made along certain lines. Greater activity has prevailed than any year heretofore, and several large installations have been completed, principal among these being the Trenton Channel plant of the Detroit Edison Co., which is the third large central station to be fired exclusively with pulverized coal. Other important installations put into service during the year include the Middletown plant of the Metropolitan Edison Co., consisting of three 14,710-sq.ft. boilers; the Valmont station of the Denver Gas & Electric Co., with four 14,000-sq.ft. boilers; three units of 27,680 sq.ft. each, at the Colfax station of the Duquesne Light Co., two units of 18,010 sq.ft. at the Cahokia station of the Union Electric Light & Power Co., and one unit of 32,750 sq.ft. at the Cecil plant of the Allegheny County Steam Heating Co. at Pittsburgh. The last-named unit, it might be recalled, is the world's largest boiler and is claimed to have the greatest capacity per square foot of ground area. Another installation of interest, inasmuch as it will burn lignite coal exclusively, is the stand-by plant of the Winnipeg Hydro Electric System, Winnipeg, Man., Canada.

Among the important plants now in course of erection are the Miami Fort plant of the Columbia Power Co. and the Peoria plant of the Illinois Electric Power Co. The most recent addition to the list of pulverized-coal users is the New York Edison Co., which has decided to install this equipment in its new Fourteenth station, for which plans are now under way.

It is estimated that since the first of the year contracts have been placed for pulverized-coal equipment to serve practically a million square feet of heating surface, and that the total heating surface now being

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[1]Acknowledgment is made to H. W. Brooks, Fuel Engineer of the United States Bureau of Mines, for much of the information under this heading.

[2]"Coal and Coke Mixture as a Water Gas Generator Fuel." W. W. Odell. Bureau of Mines Technical Paper 284.

[3]"Neuerungen im Kokereiwesen." H. Illies. Brennstoff-Chemie 5, 161-6, 189-95, 234-40 (1924) June 1 and 15 and August 1 issues.

fired with pulverized coal is well over 2½ million. The total is practically double the 1923 figure.

One of the important events of the year has been the development and adoption of water-walled furnaces for use with pulverized-coal firing. Preliminary tests on furnaces of this type installed at Sherman Creek station of the United Electric Light & Power Co. have proved conclusively that water walls have little or no effect on the combustion and that pulverized fuel can be burned at high rates of combustion in furnaces of this type. A number of these furnaces are being installed in different sections of the country, and there is every indication that the water wall or water-cooled reverberatory wall, for the larger settings at least, will replace the air-cooled walls now considered more or less standard. The size of the furnace or the ratio of the furnace volume to the heating surface is still a debatable question; the general opinion, however, appears to be that some means must be found whereby the furnace volume can be materially reduced without sacrificing efficiency or percentage of rating obtainable. In this connection the installations at Sherman Creek, where several systems of firing are being tried out, are of especial interest, inasmuch as the furnace volume is about half that usually recommended.

Well-Type Furnace for Pulverized Coal

In this particular installation a well-type furnace has just been put in service. This furnace consists of a square refractory chamber about 4 ft. on a side and 5 ft. deep, placed in the bottom of the combustion chamber. The burners are placed near the bottom of the well and tangentially to the furnace.

It would appear that there is need for extensive investigation along this line with a view to extending the use of pulverized coal in small plants where the expense of a large furnace would make the cost of the installation prohibitive. Up to the present time most of the developments and improvements have centered around the large central stations and the large furnaces, and the smaller plant, in which the largest gains in efficiency are possible, has been overlooked. In view of this the small furnace in which coal can be burned at double the present rate of combustion offers a promising field for further investigations.

Some important work along this line has already been done by the Narragansett Electric Co., in which experiments were made with an old oil-burning furnace with a low setting, the results in some ways surpassing those with higher settings. As high as 17 per cent CO_2 was obtained and combustion rates as high as 39,000 B.t.u. per cubic foot per hour. On account of refractory troubles these experiments were temporarily abandoned. It is safe to predict, however, that with the improvement now being made in furnace-wall construction and the employment of water walls, combustion rates of 40,000 B.t.u. per hour will soon be obtained satisfactorily.

Progress has been made during the year in the burning of small-sized anthracite in pulverized form. Tests conducted on several kinds of anthracite at the power plant of the Susquehanna Colliers Co. at Lykens, Pa., demonstrated that this coal with a fineness of 70 per cent through a 200-mesh screen could be burned satisfactorily and with good efficiency, whereas a fineness of 82 per cent has previously been considered necessary for satisfactory ignition and combustion.

In the development that has taken place in the different types of preparation and burning equipment the pulverizing mill has received the largest amount of attention. Two 20-ton mills have recently been put into operation at the Cahokia station. No official tests have as yet been made to determine the relative efficiency of mills of this size with the standard mills of 5 to 10 tons capacity, but they give promise of making a considerable reduction in power consumption and maintenance costs. Considerable increase in size of unit-type mills has also been made, a 10,000-lb. per hour unit mill now being in operation.

A most interesting paper on the subject was presented by Henry Kreisinger at the December meeting of the American Society of Mechanical Engineers. In the design of a furnace for the burning of powdered coal where high temperatures are prevalent owing to low excess air, two problems are uppermost; namely, the prevention of the erosion of the walls and the easy removal of the ash deposited at the bottom of the furnace. The present trend is toward nearly complete water cooling. The water screen, first used at the bottom of the furnace to prevent fusion of the ash and to facilitate its removal, met with such success that it was soon applied to the back wall of the furnace where the abrasion was great owing to the turning of the flame. Water-cooled side walls are now used in addition to the screens and all form a part of the boiler. In Mr. Kreisinger's opinion this was a natural development in furnace design, for, as he expressed it, "Powdered coal can never be a complete success until the boiler is built around the furnace."

Trend in Stoker Design

Stokers of special design for preheated air, the development of long stokers of unusually large coal-burning capacity and modifications of design so as to reduce maintenance, express the recent trends in this field. A number of superstokers have been built, the largest on record being installed in the Kearny station of the Public Service Corporation of New Jersey. The initial installation here will include twelve stokers serving 23,600-sq.ft. boilers, each being 16 retorts wide and 37 tuyeres deep with a coal-burning capacity of 30,000 lb. per hour under normal conditions. The furnace is 26 ft. wide, 16.5 ft. deep and 17 ft. high from the bottom of the crusher rolls. It is estimated that the fuel bed will weigh about 70,000 lb., and 240,000 cu.ft. of air per minute will be required to support combustion.

With stoker furnaces the tendency is also toward water-cooled walls, and a test on one such installation during the year showed a maximum over-all efficiency of more than 92 per cent.

Owing to the large boiler units and increased steaming capacities required, the same trend has been apparent in the traveling chain grate. Stokers up to 400 sq.ft. of active grate area capable of burning 20,000 to 24,000 lb. of coal per hour have been built.

On the other end of the scale an automatic underfeed stoker has been perfected to serve boilers of 1,500 sq.ft. down to the small house-heating unit and also a traveling grate for nearly the same range. This is virgin territory for fully automatic stokers, and it is gratifying to report that initial installations have proved satisfactory from the viewpoints of price, economy and smokeless operation.

Detail improvements have been made also on top-feed stokers and on the natural-draft chain grate, adapted especially to the industrial plant of moderate size.

Hand stokers have been improved by the addition of hopper feeds and power drives and, in a recent design, by the provision of a combustion arch and depression plate to introduce a mixture of preheated air and furnace gases over the fuel bed.

Sales of mechanical stokers up to Dec. 1, as reported by fifteen companies to the Department of Commerce, show a decline from the previous year. Only during October and November (December not yet reported) did the stoker business for 1924 exceed that of 1923.

In the application of stokers to locomotives, says H. W. Brooks, of the Bureau of Mines, the New York Central, Erie, and other roads have installed locomotive stokers for heavy passenger locomotives for the first time, while progress in the installation of locomotive stokers on heavy freight locomotives has continued at the normal rate of increase—a majority of the heavy locomotives built during the year being so equipped. Owing to business uncertainty the output of locomotives during 1924 has been nearly 1,000 locomotives short of the normal rate of increase.

The steamship "Swartenhondt," built for service between England and Holland this year, is the third ship which has been equipped with stokers, and a fourth vessel of the same line will shortly be put in commission. Stoker equipment apparently has proved a success since, after equipping two ships with it successfully, similar equipment has been put on a third ship and ordered for a fourth. On recent trials the horsepower developed was 3,450 against 3,100 normally, the installations consisting of four B. & W. marine-type boilers, each equipped with a mechanical stoker 6 ft. long by 12 ft. wide.

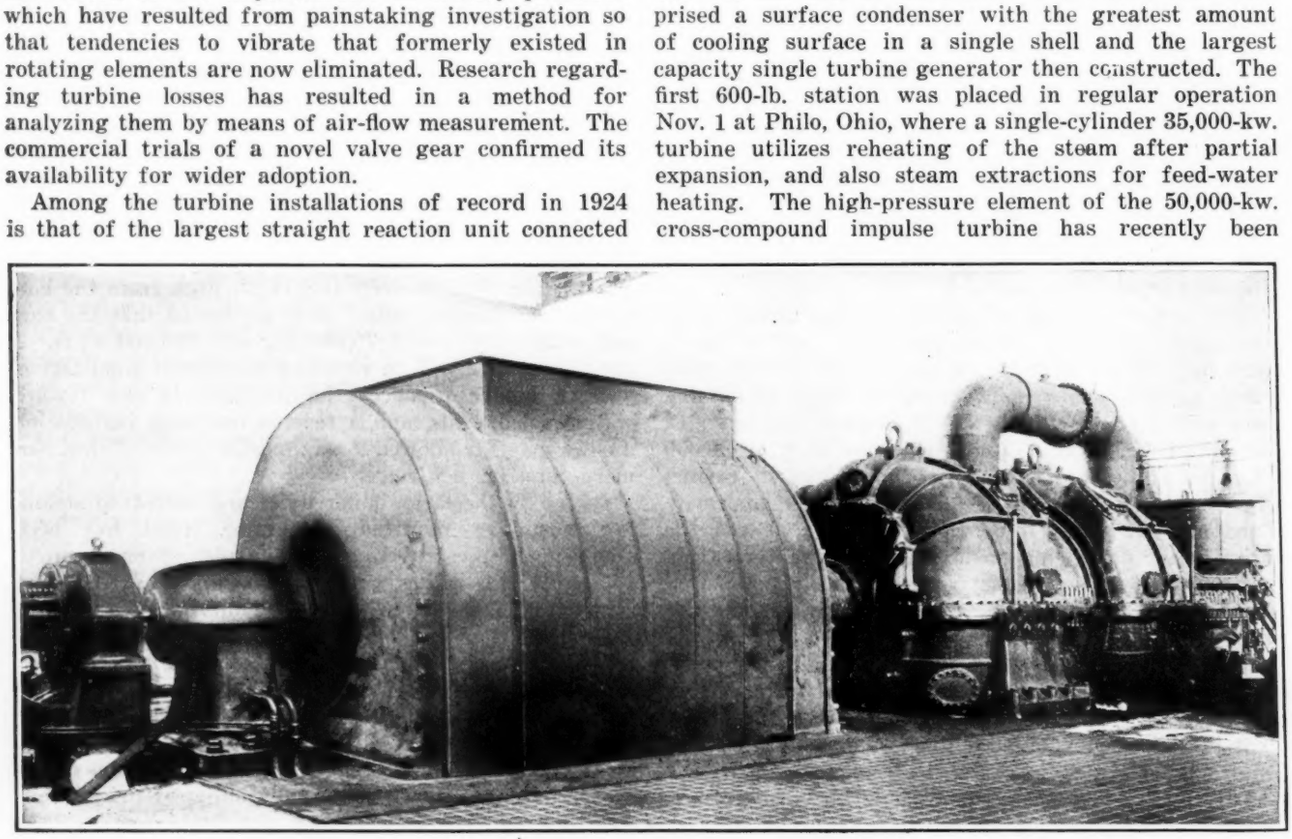
In coal handling nothing particularly new in the way of equipment has been developed, but interesting combinations have been installed in some of the later plants. Sluicing of ashes continues popular where plenty of water is available. In powdered-coal plants the electrostatic precipitation of ash dust is something new. Such a system has been installed at the Trenton Channel plant of the Detroit Edison Co., to remove the fine ash dust which otherwise would be carried out of the stack.

Refinements in Turbine Building

Methods of Factory Adjustment Safeguard Large Turbines Against Vibration—Record-Breaking Units Manufactured—New Designs of Industrial Turbines for Process Steam

IN SPITE of the fact that some remarkable units were produced during the year, attention has been focused on the improvements in factory processes which have resulted from painstaking investigation so that tendencies to vibrate that formerly existed in rotating elements are now eliminated. Research regarding turbine losses has resulted in a method for analyzing them by means of air-flow measurement. The commercial trials of a novel valve gear confirmed its availability for wider adoption.

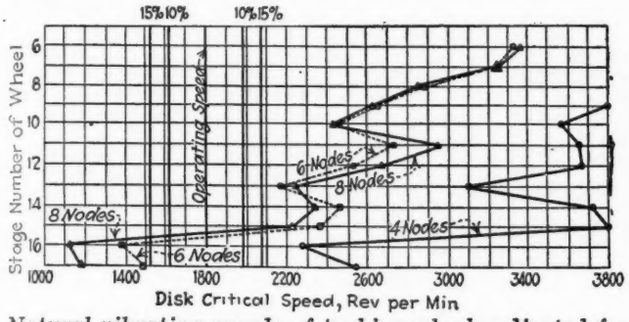
Among the turbine installations of record in 1924 is that of the largest straight reaction unit connected to a single generator and now in regular operation at the Hudson Avenue station of the Brooklyn Edison Co. At the date of installation this entire unit comprised a surface condenser with the greatest amount of cooling surface in a single shell and the largest capacity single turbine generator then constructed. The first 600-lb. station was placed in regular operation Nov. 1 at Philo, Ohio, where a single-cylinder 35,000-kw. turbine utilizes reheating of the steam after partial expansion, and also steam extractions for feed-water heating. The high-pressure element of the 50,000-kw. cross-compound impulse turbine has recently been



Westinghouse 50,000-kw. unit installed in Hudson Avenue station, Brooklyn Edison Co.

installed at the Crawford Avenue, station of the Commonwealth Edison Co., Chicago.

A 20,000-kw. reaction turbine has been in operation at the Waukegan Generating Co., Waukegan, Ill., having "end-tightened" reaction blading in the high-pressure stages. Vanes are equipped with shroud rings, and those in the high-pressure region utilize close axial instead of small radial clearance. This is the largest single-cylinder unit operated with end-tightened



Natural vibrating speeds of turbine wheels adjusted far above or below normal speed, insure smooth disk operation

A turbine wheel is represented by a horizontal line, the stage number being indicated at the left. Critical speeds for different types of vibration of a disk are shown by points on this line. It will be seen that the 15 per cent safe speed margin for 4-node is far exceeded, and the 10 per cent limit for other types of vibration is also not closely approached.

blading in this country, but it should be noted that both the high- and intermediate-pressure cylinders of the British Parsons cross compound 50,000-kw. turbine shipped to the Crawford Avenue station from England also contain this type of blading.

Many improvements have been made in details of a minor nature in the Allis-Chalmers turbines. Blade-carrying rings mounted on the turbine shaft are balanced individually before the blading is inserted, and the blade sections are then independently balanced. Each completely assembled blade-carrying ring is run to a speed of 20 per cent in excess of the normal, as a check on balancing and manufacturing work in general. The balance of the completely assembled turbine is also checked at normal speed and overspeed. The turbine cylinder horizontal joint has been improved by a design based on high unit joint pressures as contrasted with large bolted surface at low unit joint pressure as was previously utilized.

The Ford Motor Co. has built and placed in operation in its own plant a number of units having ratings ranging from 35 to 35,000 kilowatts.

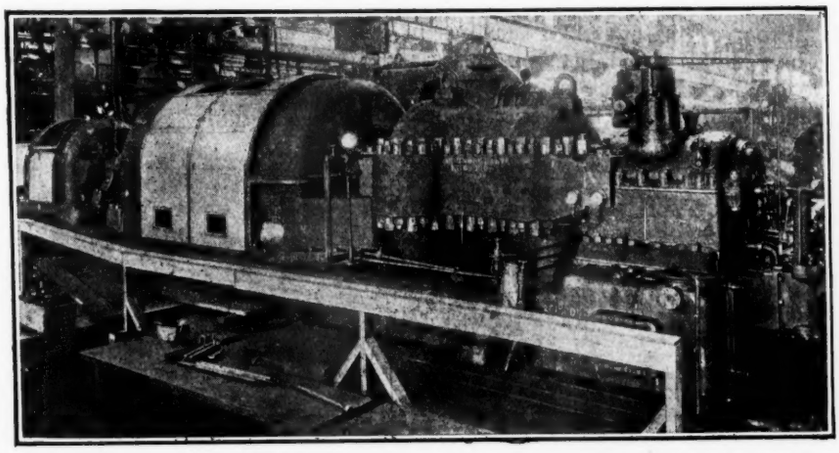
New designs of the past year are not strikingly novel. A record unit is a 60,000-kw. single-cylinder, single-flow impulse turbine for the New York Edison Company.

The manufacturers of large units have quite generally adopted the plan of utilizing a rigid steam chest with a flexible pipe connection to the turbine cylinder. Strains caused by the movement of the main steam header, and the effect of contraction and expansion of possibly a long connecting pipe to the throttle valve are thus prevented from reaching the turbine.

Emphasis during the year, however, has been placed on the problems connected with manufacturing large machines. A study of turbine-blade vibration by the Westinghouse company has revealed that natural vibrating periods obtained by calculation checked closely with those as shown by tests. Blades are designed so that the natural period is considerably above that which would correspond to normal operating conditions. In order that turbine rotors may pass a rigid temperature test, an equipment has been installed in which they may be seasoned under high temperature and also rotated while under desired conditions of temperature, pressure, vacuum and overspeed. Spindles overspeeded at a high temperature and subsequently checked in a balancing machine have demonstrated the value of this treatment when in actual service.

The vibration of turbine disks has received intensive study both here and abroad. A paper of merit by the late Wilfred Campbell, presented at the A.S.M.E., described an investigation by the General Electric Co. and the means employed for adjusting the critical speed of disks where they would be safely removed from vibration corresponding to normal speed.

Turbine vibration has been found due to critical or natural vibrating periods of disks when these corresponded closely to operating speed. By changes in design these natural vibrating periods may be removed by a safe margin from that corresponding to operating speed. Thus in the line cut shown on this page it will be seen that 4-node critical vibration for the fourteenth stage corresponds to an operating speed of about 3,700 r.p.m. This is an ample margin beyond the safe limit of 15 per cent, or 2,070 r.p.m., indicated in the figure. The critical speeds for 6- and 8-node vibration, which are less dangerous than 4-node, are also plotted for a large number of wheels. Disk vibration and consequent fatigue effects thus can be avoided. The factory routine includes an elaborate method of testing disks for vibration characteristics.



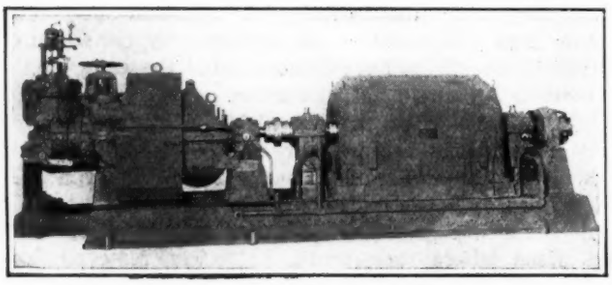
High-pressure element of General Electric cross-compound turbine for Crawford Avenue station

A contribution by Dr. B. L. Newkirk and A. L. Kimball, Jr., of the research laboratory of the General Electric Co., disclosed that the mechanical action which produced shaft whipping in flexible-type rotors is a result of the gripping action of certain kinds of sleeves and collars. Effective means of obviating such conditions were outlined.

Analyzing turbine-nozzle loss and efficiency by air-

flow measurements was described by H. Loring Wirt, in a paper, "The Turbine Designer's Wind Tunnel," presented before the A.S.M.E. during the year. This ingenious method is applicable to many commercial problems involving the flow of fluid either compressible or incompressible. It illustrates how calculations and actual results may readily be checked against each other.

Industrial units of 3,500 and 6,000 kw. of 3,600 r.p.m. for 60-cycle operation have been designed by the Westinghouse company which has also developed a new type of 15,000-kw. turbine at 1,800 r.p.m.



Multi-stage Terry turbine for high pressures

The flyball-type governor is eliminated in the new Westinghouse oil-operated valve gear. Instead, oil supplied by a pump on the turbine shaft opposes a piston counterbalanced by a spring in a novel manner. Factory tests and commercial trial indicate that some desirable characteristics are thus more easily attained than with the flyball-type governor.

Progress in industrial turbines in general has been along the lines of higher pressures and greater flexibility of design. Turbines for use as reducing valves, thus furnishing power from heat units in the high ranges of higher pressures, have been developed by the Terry Steam Turbine Co. A 550-kw. alternating-current unit has been designed for steam initially at 180 lb. gage, 100 deg. F. superheat, and exhausting at a back pressure of 115 lb. gage. Two similar machines in an industrial plant are equipped with back-pressure regulators that vary the load on the turbines so as to maintain a constant pressure in the exhaust-steam system. They operate in parallel with the main power units.

A line of these units, with a maximum capacity of 1,000 kw., has been laid out for steam conditions initially as high as 600 lb. 750 deg. F. and back pressures up to 130 lb. Diaphragms, nozzles, wheels, etc., may be utilized to meet a variety of conditions.

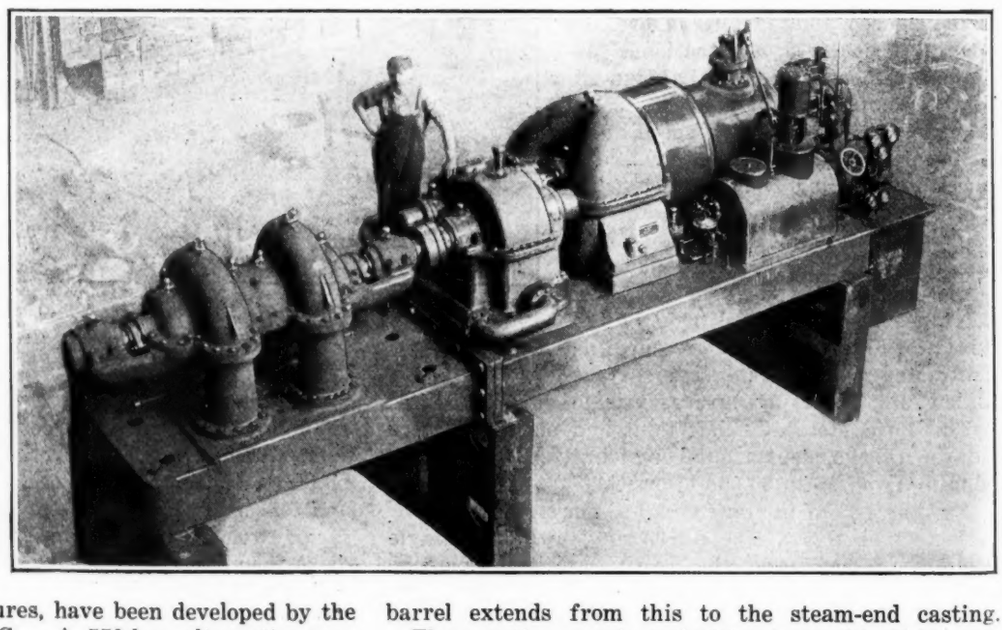
A velocity-stage turbine for extremes of pressures and temperatures, has been put out by the De Laval Co. These turbines may be obtained in capacities from 1 to 1,000 hp. at maximum temperatures. Bearing pedestals are integral with the casings and supported by single high-pressure pedestals in order to secure uniform expansion from the shaft. The steam inlet and nozzle are placed in the top of the wheel casing, so that the higher pressure and temperature will be confined as much as possible to a small region at the top of the unit. A globe-type emergency valve is independent of the main governor valve. Each nozzle is fastened to its necessary intermediate blades. If it is desired to increase the capacity, an additional nozzle, with its corresponding intermediate blades already attached to it, may be inserted as a single piece.

A worm reduction gear by the same company has recently been developed, which utilizes a tooth angle of approximately 60 deg. so as to provide more of a crushing strain rather than bending. It may be supplied for a single reduction in ratios varying from 4:1 to 100:1, and in capacities up to 500 hp. or more. It is designed so that at least three teeth are always in contact.

Industrial units have been redesigned by the Kerr Turbine Co., so that medium and larger sizes are no longer built of a number of circular rings bolted together to form the casing. The casing now consists of both an inner and an outer barrel, the former being supported by the exhaust end casting, while the outer barrel extends from this to the steam-end casting.

The practice now is to build rotors with disks comparatively small in diameter at the high-pressure end, gradually increasing to the exhaust. Buckets of the flared type provide a sharp exit angle, for greater economy.

The largest single-unit surface condenser at the time of construction was placed in operation during the year



Allis-Chalmers geared pumping unit

This pump is rated at 11,000,000 gal. per day under 400-ft. head installed by the South Pittsburgh Water Co. The two pump runners are in series. The series connection from the discharge of the first runner to the suction of the second runner is cast in the base plate, and the suction inlet to the first runner and outlet from the second runner extend down through the base, so that all connections are made from below.

at the Hudson Avenue station. This contained 70,000 sq.ft. in 13,368 tubes. Its greatest diameter is 22 ft. 7 in., length 30 ft. 8½ in., and it weighs approximately 300 tons. Improvements in hotwell of condensers have led to the deaëration of condensate being carried out in a more positive manner. Water seals prevent the removal of exhaust steam along with the condensate.

Single-flow condensers with external air coolers have been placed in operation, serving 30,000-kw. and 35,000-kw. turbines by the Wheeler Condenser & Engineering Co., and the Ingersoll-Rand Co. respectively.

A complete set of tools for pulling plugs and removing tubes were developed by James McPherson, as described in the June 24, 1924, issue. This made possible an unusually short period for removing the tubes of a large surface condenser. Methods of cleaning condenser tubes have been developed by the Ingersoll-Rand Co. wherein special blowoff nozzles remove débris from the tube sheet and other parts.

Valves and Fittings

When it was realized several years ago that increased pressures and temperatures were economically desirable, the impression prevailed to some extent that valves and fittings for extreme conditions were not at that time generally obtainable. While the steam turbine could be readily adapted to higher temperatures and pressures and boilers did not present any apparently serious impossibilities for such operation, valves and fittings seemed to be, to some extent, the limiting factors.

At the present time it appears that, if anything, valves and fittings occupy a strategic position in their relation to progress in pressures and temperatures. This appears to be due to two conditions. In the first place, designs of valves and fittings were quickly developed to meet the new conditions, and secondly, the adoption became more general of processes in oil-refinery operation, wherein pressures at least equal to those of maximum steam practice and temperatures appreciably above were encountered. As a result many manufacturers are equipped with standard apparatus for high pressures and temperatures of 800 to 1,000 deg. F. developed from refinery practice.

A fundamental change in materials for valves and fittings has taken place during the last year. Elaborate specifications dealing with the manufacture, heat treatment and tests of fittings, etc., have been made standard. As a result, cast steel has been removed from the class of possibly unreliable material to that of the direct opposite. Improved practice in the foundry and elaborate tests including, if necessary, the location of flaws by X-ray analysis, have resulted in a product whose qualities, as required by high temperatures and high pressures, are definitely and reliably measured. Forged-steel valves and fitting developments are also prominent, representing refinery temperatures and pressures.

The result of the general adoption of high pressures and temperatures is noted all along the line, including small valves, pipe joints, traps and fittings. A seatless blowoff valve, for instance, has been changed in design so as to eliminate the shock of the incoming steam during the blowoff action. This is accomplished by providing two sleeve openings opposite to each other, so that the incoming steam paths are opposed and shock on the sleeve itself practically eliminated.

Water-Power Development Affected by Many Retarding Influences

Large Amount of Construction Work Completed—New Orders Have Not Kept Pace with Projects Completed—Record Made for Size and Head for Both Impulse and Reaction Wheels

WHEN measured by the amount of construction work actually under way, 1923 was probably the banner year in water-power development. During 1924 construction work probably equaled that of 1923 and a number of the big projects were either completed or carried along well toward completion, but other developments have not been projected to take their place in the manufacturing field. As a result of this it appears that for the next year or so there will be a slack period unless some of the large proposed developments which are now tied up for various political reasons are started. A great many projects are under way, but for the most part they are comparatively small when viewed as we have become accustomed to view large water powers.

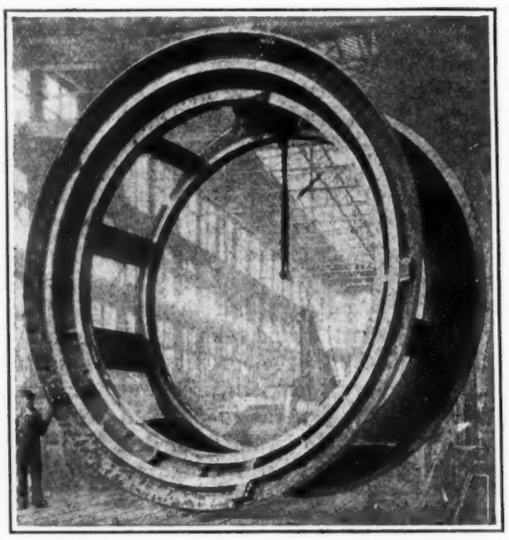
When the Water Power Act was passed by Congress, it was hailed as a boom to water-power development. These expectations have been in a way fulfilled as shown by the facts, that applications have been filed with the Federal Water Commission for a total of nearly 25,000,000 hp. for the first four years that the act has been in force, as shown by the Commission's fourth annual report. During this period, ended June 30, 1924, sixty-seven projects with a prospective installation of 2,782,000 hp. were completed or placed under construction, of which 18, with a combined installation of 259,000 hp., were started during the Commission's last fiscal year.

However, the experience of the last four years and a half has shown that it is one thing to have constructive legislation enacted and quite another to carry into effect the intent and purpose of the statute. Almost from the very first the administration of the Federal Water Power Act met with opposition from state, municipal and other local government and private agencies, but this is becoming more involved and unless some of the tangles are soon cleared away it cannot help but react detrimentally to water-power development. In fact, the effects of this lack of accord between different government agencies on water-power development is undoubtedly already retarding progress.

On the Pacific Coast irrigation, fishery and in some cases municipal water supply interests are clashing with water-power development. In California the Kalmath

River has been set aside for all time as a fish preserve and withdrawn from water-power development.

Another influence, and a natural one, is the droughts that have occurred during the last few years. These have caused serious power shortages in the Southeast and on the Pacific coast, where a large percentage of the supply comes from water-power developments. These shortages have caused large steam stations to be



Cast-steel speed ring for one of eight 45,000-hp. Allis-Chalmers turbines being installed by the Quebec Development Company

built or started in these sections. These plants probably would never have been undertaken if water-power developments had not failed to meet the demands. Just how much this condition may affect water-power development it is too early to predict. Of course in a large section of the country, where steam power predominates, this is not an influence; but where the largest amount of water power can be absorbed and where the supply would be practically continuous, development is being held up awaiting the clearing away of international political tangles. This is particularly true of the St. Lawrence.

The State of Maine has an abundance of water power but lacks the industries to absorb this power and will not allow it to be exported out of the state to the large industrial centers where it could be used.

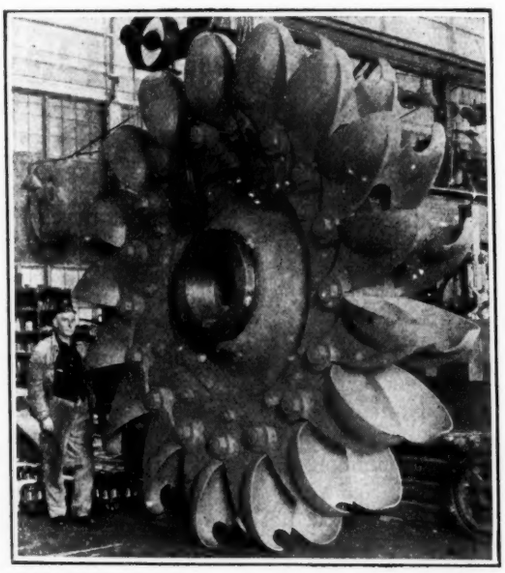
Many of our rivers have not been properly surveyed, and it is impossible to carry out an intelligent water-power development program until this has been done. This could be done with the fee obtained from permits and licenses for water-power developments, but up to the present time Congress has not seen fit to allow money obtained from water-power developments to be expended in the interest of this one of our greatest natural resources.

Considering all these facts, it is not difficult to see why water-power development has already begun to lag and may continue to do so if some of the difficulties that are in its way are not adjusted in the near future. However, this does not make our water powers of any less value to the country, but only delays realizing their full benefit. This should not be construed as meaning that the bottom is going to drop out of the water-power business, since there is a vast amount of the small and medium-sized developments that will be held to tide over until the time arrives when the large projects may be developed.

Of the four large water-power undertakings—Muscle Shoals, the Colorado, Columbia and St. Lawrence Rivers—referred to in last year's report, the only one of which material developments can be reported is the first-mentioned. The federal government is rapidly carrying to completion its development at Dam No. 2 (Wilson Dam) and by the end of this year should have 260,000 hp. installed in eight units. Four of these are rated at 30,000 hp. and four at 35,000 hp., the latter being ordered during the last year. This plant, when completed, will have a total capacity of 610,000 hp. in 18 units.

The long-projected Conowingo development on the Susquehanna River in Maryland took a favorable turn about the middle of last year, but has since met with reverses. The Susquehanna Power Co. has made an application to the Federal Water-Power Commission for a license covering the project, which involves developing 300,000 hp. and the construction of a dam 90 ft. high by 4,400 ft. long. This application is now being held up by the Federal Water Power Commission until it is determined if the Conowingo site is the proper place for a dam that would permit complete use of the flow available. What has occurred in this project is a good example of why comprehensive surveys should be made of our rivers and the power development planned with respect to the river as a whole.

During the year a license was granted to the Alabama Power Co. to develop 114,000 hp. at five sites on the Tallapoosa River. This development is known as



Runner for one of four 25,000-hp. Pelton Water Wheel Co.'s impulse wheel in the City of San Francisco's Moccasin Creek development

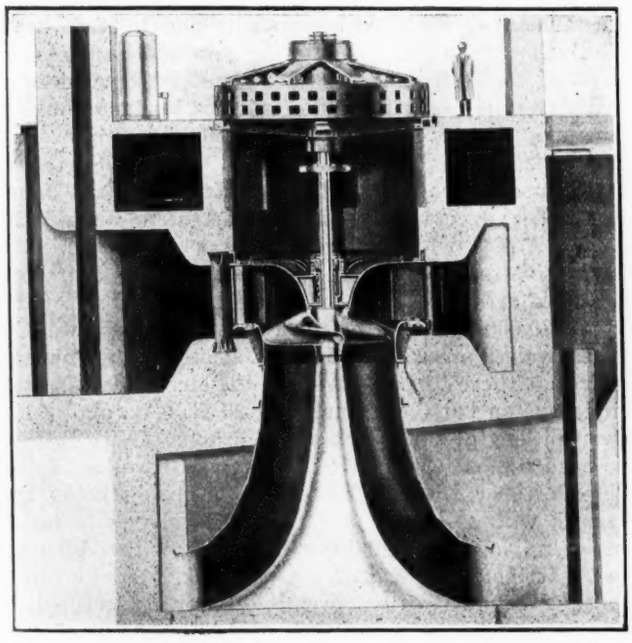
the Cherokee Bluffs project and will cost, according to estimates, $39,000,000. Another important undertaking for which a license was granted during the year was the Wallenpaupack Creek development of the Pennsylvania Power & Light Co. This project will develop 57,000 hp. in two 28,500-hp. units to operate under 330-ft. head, for which the contract has been let. These turbines will have cast-steel casings and bronze runners. Contracts were let for two 24,500-hp. turbines

to operate under 300-ft. head for the Exchequer Plant of the Mercer Irrigation District. These units also have cast-steel casings and, like the Wallenpaupack turbines, the draft tubes will be provided with removable sections for quick replacement of the runners from below the turbine casing. The removable draft-tube sections will have provision for attaching special car wheels running on tracks by which the sections can be quickly removed and replaced.

A number of other contracts have been let for turbines in the eastern part of the country, but with the exception of the four 35,000-hp. units for the Muscle Shoals development, they have for the most part been for capacities of 20,000 hp. and less. One company reports a contract for three 13,000-hp. units from the Gifu Electric Power Co. of Japan. These machines are to operate under a head of 169 ft.

On the Pacific Coast the most noticeable construction work under way is the Pit River No. 3 plant of the Pacific Gas & Electric Co. This project will have three 35,000-hp. vertical turbines to operate under a 280-ft. head and is expected to be ready for operation in July, 1925. Its cost is placed at $13,000,000. These units are equipped with motor-operated valves, and the runners will be fitted with rubber seal rings. The draft tubes will be of the Moody spreading type and will have a steel lining.

Another Pacific coast project that has been attracting considerable attention is the City of San Francisco's Moccasin Creek plant. The four 25,000-hp. machines

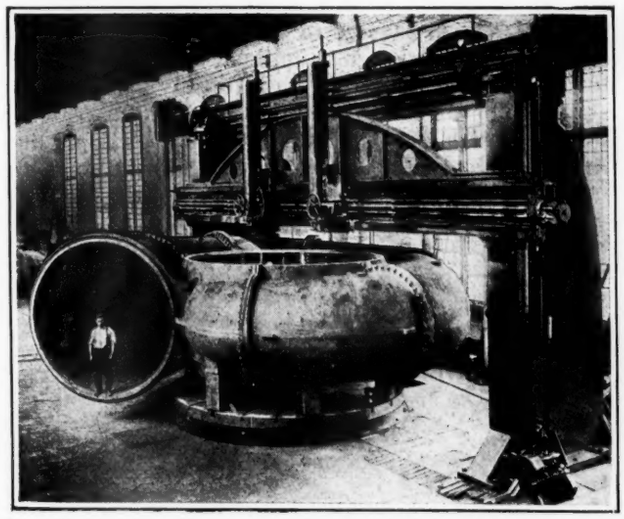


One of five 1,500-hp. Wm. Cramp & Sons' propeller-type turbines installed in the Moreau Manufacturing Co. plant to operate under 15.5-ft. head

being installed in this plant were shipped during last year. They are of the impulse type to operate under a head of 1,250 ft.

A new record for size was established last year for impulse wheels in a contract let by the Southern California Edison Co. for a 35,000-hp. unit to operate under a 1,900-ft. head at 300 r.p.m. This unit is to be installed in the company's Big Creek No. 1 plant. The largest impulse wheels constructed previous to this unit were for 30,000 hp., three of which have been installed in the Caribou plant of the Great Western Power Co., to operate under a 1,000-ft. head.

A new record was established for high-head Francis type turbines when the Oak Grove plant of the Portland Electric Power Co. went into service. This plant will eventually have three 35,000-hp. vertical-shaft units to operate under a head varying from 930 to 850 ft. Previous to this the two 25,000-hp. turbines in Kern River



Scroll case for one of two 40,000-hp. S. Morgan Smith Co.'s turbines used in the City of Seattle's Skagit River development, under 275 to 375-ft. head

No. 3 plant of the Southern California Edison Co. held the record under an effective head of 810 ft. All three of these machines are equipped with rubber seal rings.

During the last year the Skagit River development of the City of Seattle went into operation. The initial installation comprises two 40,000-hp. vertical-shaft units to operate under 375 ft. head at 257 r.p.m.

The most notable plant to go into service during the year was Hydraulic Plant Extension No. 3 of the Niagara Falls Power Co. This plant contains three 70,000-hp. units to operate under 212 ft. head. These are the most powerful machines that have ever been constructed. Two of them have cast-steel casings and one a plate-steel casing. The first one has been in commercial operation for over 10 months and all three are now in service. Their satisfactory performance has demonstrated that the many engineering problems involved in their design have been successfully solved.

In Canada some notable work has been done. The Quebec Development Co. is about to put in operation the first 45,000-hp. unit in its Lake St. John plant on the Saguenay River. This plant is laid out for twelve machines of this rating, eight of which will comprise the initial installation which is the largest single contract ever let for hydraulic turbines.

The ninth unit was ordered for the Queenston plant of the Hydro-Electric Commission of Ontario. When this machine is installed, it will give this plant a total capacity of 520,000 hp., with provisions for two more units.

In point of size a new record was established for propeller-type turbines with the installation of four 30,000-hp. units in the La Gabelle plant of the St. Maurice Power Co. on the St. Maurice River about seven miles below Shawinigan Falls, Que. These units oper-

ate under a head of 60 ft., which will later be increased to 65 ft. A number of other installations representing further development of high-speed propeller-type turbine for low-heads have been completed in this country and Canada.

A design of particular interest resulting from a study of the possibilities of reducing the turbine cost for low heads is that of the five units for the Illinois Northern Utilities Co., Dixon development, each unit having a capacity of 800 hp. at 80 r.p.m. under a head of 8 ft. This is believed to be the lowest-head development ever undertaken with units of such capacity. The turbines are provided with separate stay vanes attached at their upper ends to a ring constructed of plate and structural steel continuous with a plate-steel pit liner. Another recent design of low-head propeller-type turbines is that for the Southern Canada Power Co., involving two units of 6,000 hp. each, at a speed of 138.5 r.p.m. under a head of 30 ft.

Runner for one of four 30,000-hp. Dominion Engineering Works turbines installed in plant of the St. Maurice Power Co., Quebec; head 60 feet

Two units of the propeller type are being built for the Manchester Traction, Light, Heat & Power Co., Manchester, N. H., one of which is rated at 4,700 hp. and the other at 3,500 hp. to operate under a 30-ft. head. The Feeder-Dam plant of the Moreau Manufacturing Co., containing five 1,500-hp. propeller-type units, went into service during the last year, to operate under a 15.5-ft. head.

The final test curve for unit No. 5 of the Queenston-Chippewa development at Niagara Falls was issued during the present year and showed a maximum turbine efficiency of 93.3 per cent. Test results of the 70,000-hp. turbines of the Niagara Falls Power Co. are expected to be announced in the near future. Both of these plants were tested by the Gibson pressure-time method.

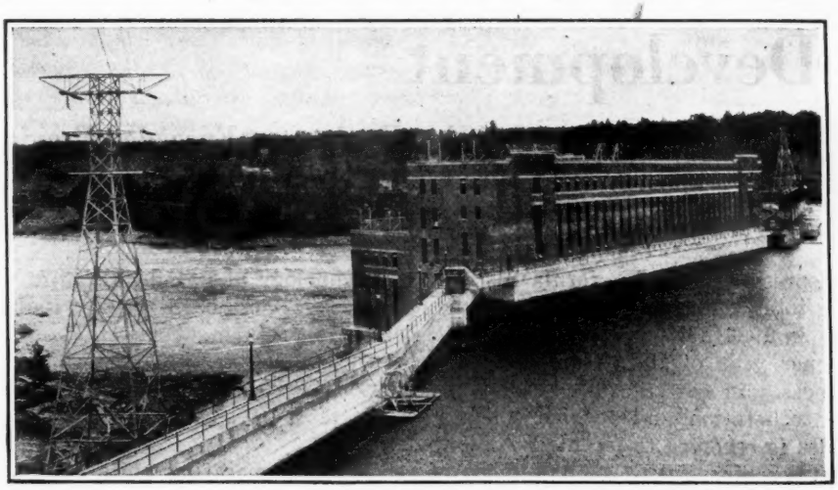
The two 20,000-hp. turbines at the Holtwood plant of the Pennsylvania Water & Power Co. were tested by Prof. C. M. Allen's salt-velocity method. An efficiency of 92.8 per cent was secured from these turbines, which is considered particularly creditable in view of the space restrictions imposed on the design due to the installation of these units within a space originally provided for 13,000-hp. two-runner machines. Efficiency tests on propeller-type turbines at Anson, Maine, and at Kapuskasing, Ontario, made by the same method, have shown an efficiency of 90.9 and 90 per cent respectively. Specific speeds corresponding to these efficiencies are 143 and 128 respectively in the foot-pound system. The Anson test is believed to represent the highest efficiency ever secured in an actual installation of a turbine of the propeller type.

Draft-tube design has continued to attract attention. Tests have been made that have added considerable to the knowledge on this subject. Although no radical changes in design have taken place during the last 12 months, improvements are being made that simplify and reduce the cost of construction. Among the changes are such features as supporting the bell on stay vanes under its lower end, improved methods of reinforcing the tube and using steel linings so as to save the cost of the expensive wooden forms that have been used in the past.

Automatic hydro-electric plants established two new records during the last 12 months. The Sprite Creek plant of the Adirondack Power & Light Co. went into operation. This plant has a capacity of 7,300 kva. in one unit, operates under a head of 370 ft. and is full automatic. Another plant that shows the trend in size and head that may be employed for automatic stations is that of the City of Colorado Springs, Colo. This installation is for 1,450-hp. capacity and 1,000-ft. head. Both these plants are records for size and heads. Outside of these installations there has been considerable activity in the construction of automatic plants, but for the most part the units have been of comparatively small sizes.

Penstock valves, both of the butterfly and the Johnson types, received considerable attention during the year. A record for size and head was established. The largest valves of the butterfly type that have ever been installed are those in the mouth of the penstock of the three 70,000-hp. units of the Niagara Falls Power Co. These valves are 23 ft. 6 in. in diameter. The Johnson valves at these turbines are also the largest constructed and have an outside diameter of 25 ft. 9 in. and 30 ft. over-all length, and weigh over 300 tons. With respect to head the butterfly valve on the Oak Grove turbine of the Portland Electric Power Co. probably holds the record, with a head of 930 ft. This valve is installed between the penstock and turbine casing with a Johnson valve at the upper end of the penstock. The butterfly valve is operated with a reversible water motor supplied from the penstock. A new type of butterfly valve was put into commercial service during the year on the Davis Bridge project of the New England Power Co. and is known as the disk-arm type. Instead of operating the valve from a crank on the disk shaft, a connection is made to the lower side of the disk in such a way that pressure is applied to force the disk tight on its seat.

Tests have been made on Johnson valves to determine their reliability when closing in flowing water. One of the 70,000-hp. units at Niagara Falls was shut down in this way successfully, starting with the unit under full load. The valve closed in about four minutes without showing any signs of distress.



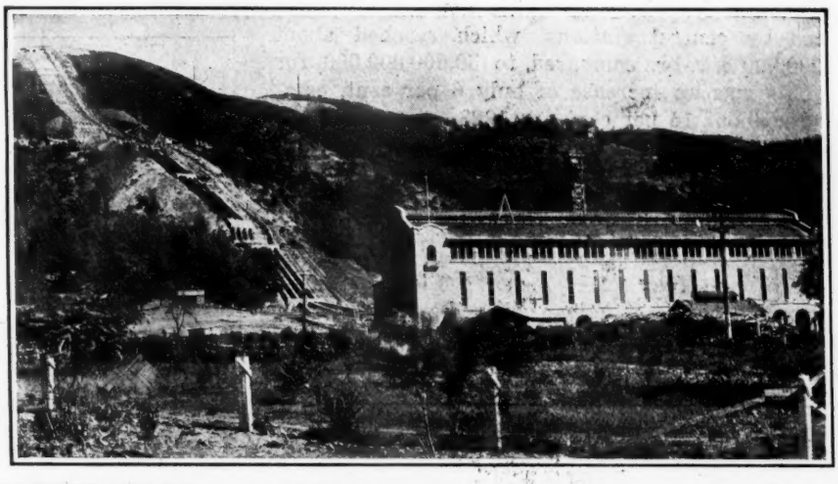
Representative Hydro-Electric Plants of 1924

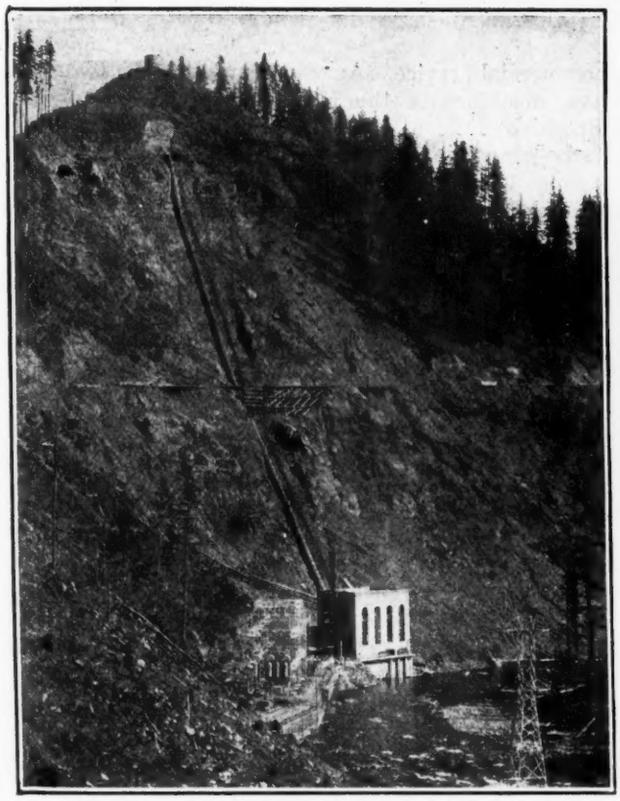
Left—La Gabelle plant of the St. Maurice Power Co. near Shawinigan Falls, Quebec. This plant is laid out for five 30,000-hp. propeller-type turbines, to operate under a 65-ft. head, four of which are in service

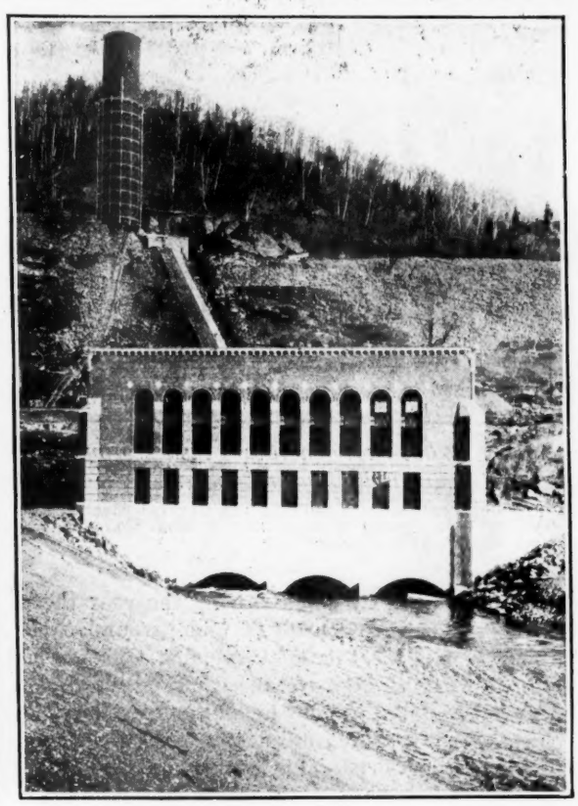
Right—City of San Francisco's Mocassin Creek plant, in which are being installed four 25,000-hp. impulse wheels 1,250-ft. head

Below, Left — Oak Groove plant, Portland Electric Power Co., laid out for three 35,000-hp. reaction turbines for a head of 850 to 930 feet

Below, Right—Davis Bridge plant, New England Power Co., to contain three 20,000-hp. units to operate under a 300 to 390 ft. head





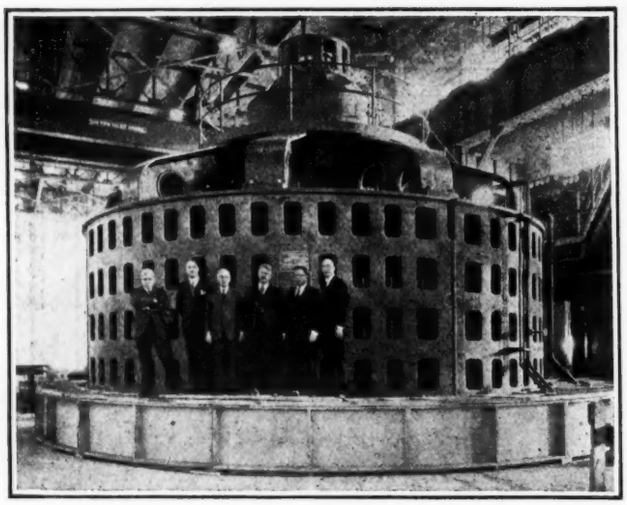


Electrical Power-Equipment Development

Volume of Business for Power Generating and Transforming Equipment Exceeded Previous Years—Number of Record Size Machines Put Into Operation and Others Under Construction—New Designs and Applications of Alternating-Current Motors

ON ACCOUNT of the business depression during the early part of the year the total volume of sales for the electrical industry in 1924 did not come up to 1923, which was the banner year of the industry in point of amount of business. In certain branches of the industry such as central-station and substation equipment the volume of sales is reported to have exceeded all previous years. General business conditions showed its effect upon the amount of power generated by central stations, which reached about 53,000,000,000 kw.-hr. compared to 50,000,000,000 for 1932. This was an increase of only 6 per cent, compared with about 16 per cent for 1923, over 1922.

Although transmission voltages have not been increased, the use of 220,000 volts is being extended, as shown by the announcement during the latter part of the year, that the Phœnix Utility Co. is building a line for operation at this voltage from its Wallenpaupack hydro-electric development to Siegfried, Pa., a distance of about 60 miles. This is the first line for this voltage east of the Pacific Coast, where there are



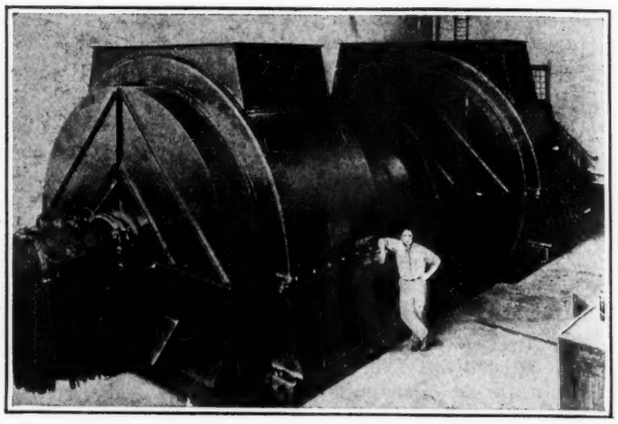
One of three 65,000-kva. generators installed by the Niagara Falls Power Company

Two of these generators were built by the General Electric Co., two turbines by Wm. Cramp & Sons Ship & Eng. Co., and one complete unit by the Allis-Chalmers Company

two such systems in operation. During the year there went into operation the 66,000-volt underground cable 8½ miles long across the City of Cleveland, Ohio. The tendency in the use of high-voltage cable is shown by the 110,000-volt installation now under commercial tests at the North Albany switching station of the Adirondack Power & Light Corp. This is the highest-voltage cable that has ever been used in this country.

The 1,000,000-volt testing laboratory of the California Institute of Technology at Pasadena, Calif., was completed during the year. This is the first of its kind outside of electrical manufacturing companies' plants. Equipment for a 1,000,000-volt testing laboratory has been ordered by the Commonwealth Edison Co., Chicago, which will be the first of the type to be installed by a central-station company.

A number of record-size generating units went into



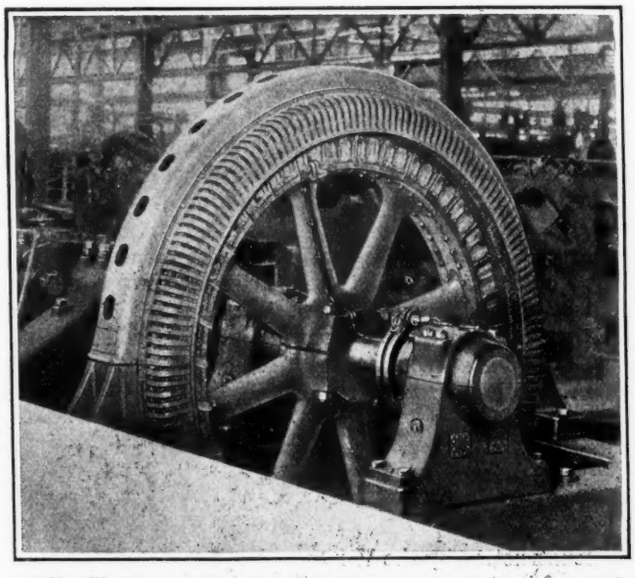
Westinghouse 35,000-kva. frequency-changer set

commercial service. Among them were the two 62,500-kva. machines in the Hudson Avenue station of the Brooklyn Edison Co. These are the largest steam turbo-generating units ever built and operate at 1,200 r.p.m. The rotors for these machines weigh 230,000 lb. each and were assembled as a complete unit at the factory and shipped as a single piece. The manufacturers emphasize the fact that the limit in size of such units operating at 1,200 r.p.m. is determined only by the machine-tool, handling and shipping facilities and not by any limitation inherent in the design. A new type of balancing machine has been developed which allows accurate balancing of rotors weighing up to 30,000 pounds.

One manufacturing company reports that it has under construction turbo-generators rated at 43,750 kva. at 80 per cent power factor and 47,000 kva. at 85 per cent power factor for operation at 1,800 r.p.m. This same company reports that the first unit of a new line of 1,800-r.p.m. turbo-alternators was placed in operation during the year. This design is for ratings of 15,000 to 35,000 kw., and since these machines were placed on the market 35 units have been sold, aggregating over 1,000,000 kva. capacity. Another manufacturer reports under construction 62,500-kva. 1,800-r.p.m. and 60,000-kva. 1,500-r.p.m. single-unit machines, which will represent a record in capacity for units operating at these speeds.

For machines operating at 3,600 r.p.m. a record was established during the year with a unit going into operation having a capacity of 12,500 kva. The difficult problems of ventilation involved in this design on account of the rotor's small diameter and great length, were successfully met without recourse to a separate motor-driven fan.

Among the notable waterwheel generator installations, the three 65,000-kva. units of the Niagara Falls Power Co. went into commercial operation during the last twelve months, although one of these machines was



Allis-Chalmers 800-hp. synchronous motor connected directly to a steel rolling mill

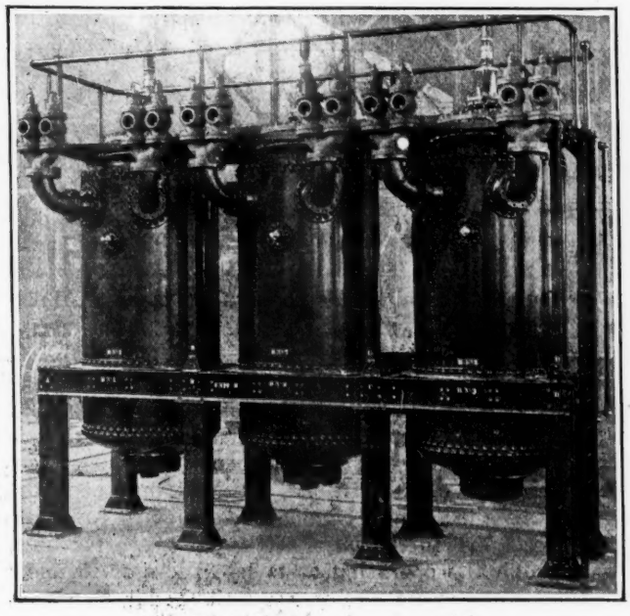
started in the latter part of December, 1923. These are the largest waterwheel generators that have ever been built and are designed to operate at 107 r.p.m. and generate 12,000-volt 25-cycle current. The rotating element of a complete unit weighs 1,100,000 lb. and is carried on a Kingsbury thrust bearing designed for a load of 1,250,000 lb. Each machine with its step-up transformer represents a complete generating station with all auxiliary equipment. Power for driving the auxiliary motors is supplied from a small 2,300-volt machine mounted above the main generator.

Interconnection of large power systems has created a demand for machines of large capacity for transferring large blocks of power from a system of one frequency to a system having a different frequency. In last year's review two frequency-changer sets were reported having a capacity of 35,000 kva. each. This year has broken that record for size with an order for a machine having a continuous rating of 40,000 kw. at unit power factor, when converting from 25 to 60 cycles, and 38,000 kw. in the reverse direction, to be installed in the East River station of the New York Edison Co. This set is similar to the 35,000-kva. induction synchronous frequency converter, built in 1923 for Hell Gate station of the United Electric Light & Power Co., New York City, which has been in operation for over a year. Tests on this unit showed that by slight modification in the 25-cycle machine 5,000 addition capacity could be obtained in the new set with the same dimensions as the first machines. The 40,000-kw. machines will be equipped with a phase-shifting device so that it can be parallel with the present Hell Gate set and also to make possible any desired division of the load between the two sets of machines.

One of the 35,000-kva. frequency-changer sets, previously referred to, under test had an over-all efficiency of 96.1 per cent, or an efficiency for each of the machines of better than 98 per cent.

For satisfactory operation of the usual types of frequency-changer sets it is necessary that a fixed relation be maintained between the frequencies of the two systems. During the year there was put into service by the Rochester Gas & Electric Co. two 7,500-kva. sets that will allow a total variation of 9 per cent in the two system frequencies. This set is known as Scherbius Controlled Speed-Regulating type of equipment. Each set consists of a 7,500-kva. 11,000-volt three-phase 60-cycle synchronous generator connected directly to an 8,500-hp. 11,000-volt three-phase 25-cycle wound-rotor type motor. Scherbius regulating equipment is provided for the latter, consisting of a separate 300-kva. regulating set.

Power-factor correction continues to attract attention, and on the large interconnected high-voltage systems voltage regulation must also be considered.



Dominion Engineering Works 30,000-kw. electric steam boiler for operation on 6,600-volt three-phase current

This has created a demand for large synchronous condensers. How large these machines may be built would be difficult to predict, but the last year has seen their size grow to 40,000 kva., an increase of 10,000 kva. over the three 30,000-kva. machines of the previous year. Such machines operate with losses less than 2 per cent of the kilovolt-ampere rating of the machine. One large manufacturing company reports that synchronous condenser applications are scarcely ten years old, yet it has installed nearly 1,000,000-kva. capacity of large sizes on transmission lines.

For automatically controlled substations orders are reported for about 50 rotary converters and motor generators in sizes of 1,000 to 2,500 kw. These are for use in railway work and Edison three-wire direct-current systems. The largest automatically controlled motor-generator set in the world was put in operation last

year. It consisted of a 5,250-hp. synchronous motor driving two 1,875-kw. direct-current generators operated in parallel on Edison service.

Although nothing radical has taken place in the field of large transformers, they continue to form a large block of the electrical business. There is a strong tendency toward the use of the self-cooled type. During the year the two largest three-phase transformers of this type were put into operation. These are rated at 15,000 kva. 60 cycles 72,000 to 132,000 volts with a 12,410 tertiary winding, and operate with an efficiency better than 99 per cent from one-half to full load and a regulation of 1.1 per cent. In addition to these two 15,000-kva. self-cooled transformers 34 others of the same capacity have been reported as being completed or under construction during the year. The tendency in the size of power transformers to meet the requirements of large power systems is shown by the report that one company has either shipped or put into operation during the year 49 transformers of rating ranging from 10,000 to 15,000 kva. and for voltages of 88,000 to 145,000.

Some notable motor aplications were reported during the year. Among these was the application of three 800-hp. 2,200-volt unity-power synchronous motors to main roll drives in steel mills. These motors are coupled directly to the mills without any clutch. Another synchronous-motor application to rolling mills is that of two 580-kva. 0.70 power factor units of the revolving-frame type. Two brush-shifting adjustable speed alternating-current motors have been applied to rolling mills. These motors are rated at 600 to 200 hp. at 307 to 102 r.p.m. and operate on 440-volt 25-cycle current.

Among new developments reported is a synchronous motor with a built-in magnetic clutch, which allows the motor to start loads up to its pull-out torque. When starting, reduced voltage is applied to the machine and the rotor comes up to speed with the shaft remaining stationary. When the rotor reaches near full speed, the field coils are excited and line voltage is applied to the stator, after which the clutch coil is excited and the load is brought up to speed.

Another new development is that of a synchronous motor for driving air and ammonia compressors. This type of motor has a double squirrel-cage winding in the rotor which permits the motor to be thrown on full voltage for starting.

Electric steam boilers continue to attract considerable attention, particularly in Canada, where there are large volumes of cheap water power and the price of coal is high. One Canadian company reports manufacturing four 30,000-kw. units during the last year, in addition to a number of smaller units.

Use of Oil Engines Has Increased

PROBABLY the events of no single year have had such a bearing on the future of the oil engine as have those of the one just ended. In fact it can be stated that the advances registered place the Diesel in the position of being an acceptable prime mover for large as well as small plants.

Heretofore the oil engine has been used almost exclusively in small power plants; the average capacity per unit, considering all engines built since 1904, has been under 400 hp. As a consequence the initial cost has been high. An additional handicap has been the inability of the owners of small factories to raise the funds necessary to the purchase of an expensive unit, even though the operating costs be so low as to make the total cost per unit of power less than with a less expensive machine.

The more extended use of deferred-payment contracts has lessened this handicap, but the strengthening of the position of the Diesel is more directly due to the increase in the unit capacity. This, by enlarging the horsepower range, has made the engine available or will make it available to industries having need of prime movers up to 5,000 horsepower.

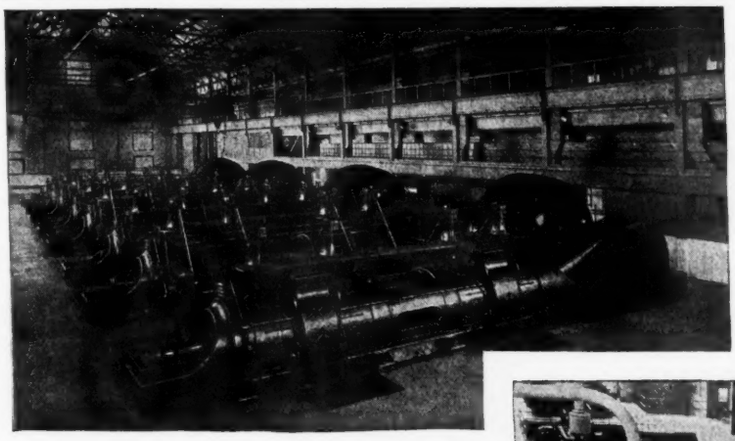
While the Shipping Board has spent an immense amount of time and money in investigating the possibilities of the motorship, the initial step in purchasing oil engines of suitable powers was completed in November. This contract covers 18 engines of from 2,700 to 3,300 hp., distributed among seven builders. While the majority of the bidders had not built engines of such a size, all have progressed beyond the drawing-board phase. Of special significance is the fact that some of these engines are to be double-acting, both two-stroke and four-stroke cycle. That the Shipping Board was willing to accept double-acting two-stroke-cycle engines is due to the developments in Europe and to the successful construction by the Worthington Pump & Machinery Corp. of its two-stroke-cycle double-acting engine at the Buffalo works.

The size permissible in oil engines is governed by cylinder stresses. Past limitation has apparently been overcome by improved design and choice of suitable materials, such as the use of forged steel for the cylinders. That the large units are available for stationary as well as marine use is evidenced by the number of bidders on the Panama job covering 3,750-hp. Diesels. There is no reason why engines of even 10,000 hp. should not be constructed.

The development of large units makes the question of equipment of large central stations and individual plants with oil engines a live topic. Current quotations on large engines, even when the development costs must be borne by but a few units, prove that the installation costs are under that of a modern steam-turbine plant. As the number of units built increases, the manufacturing costs will, of course, be reduced. Even now one builder states he is in a position to supply engines of from 3,000 to 6,000 hp. at $35 per horsepower, which means an installed cost per kilowatt capacity, including all accessories, of under $80.

That Diesel builders realize that the logical field is in the larger units is indicated by the experiments many are conducting on the solid-injection engine. The thought has been expressed by several prominent manufacturers that below 300 or 400 horsepower the Diesel must logically give way to the cheaper engine. In fact more than one Diesel builder has a solid-injection engine far beyond the experimental stage.

The builders of the airless injection engine do not entirely agree as to the size limitation set by the Diesel builder and so are increasing the maximum unit capacity. The De La Vergne Machine Co. have designed and

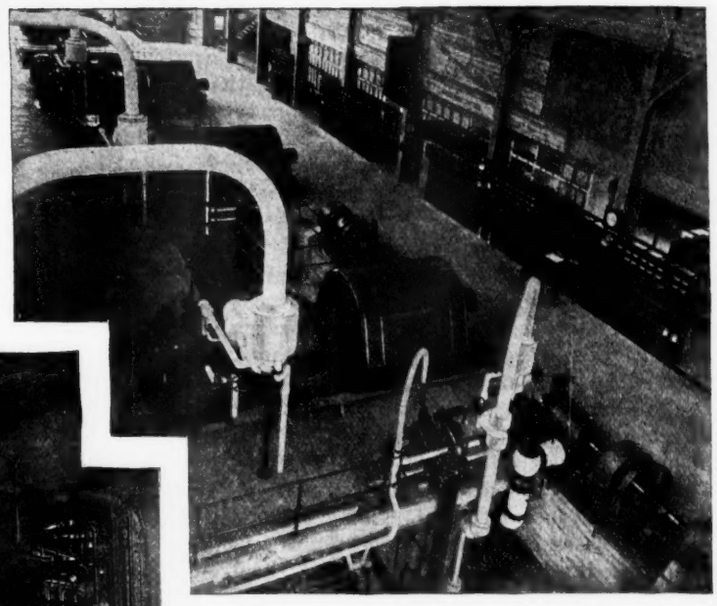


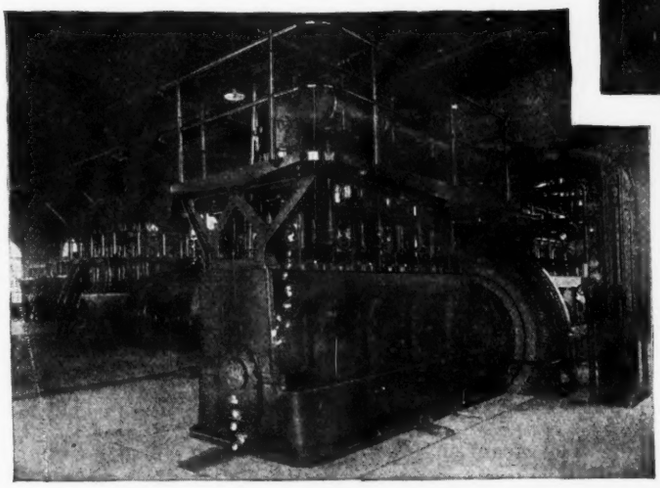
Representative Industrial Power Plants of 1924

Left—Illinois Steel Co.'s blast-furnace gas-engine plant. Four 3,330-kw. units installed

Right—Long Bell Lumber Co.'s 18,000-kw. plant. Provisions have been made for doubling the present capacity. Boilers fired with hog fuel

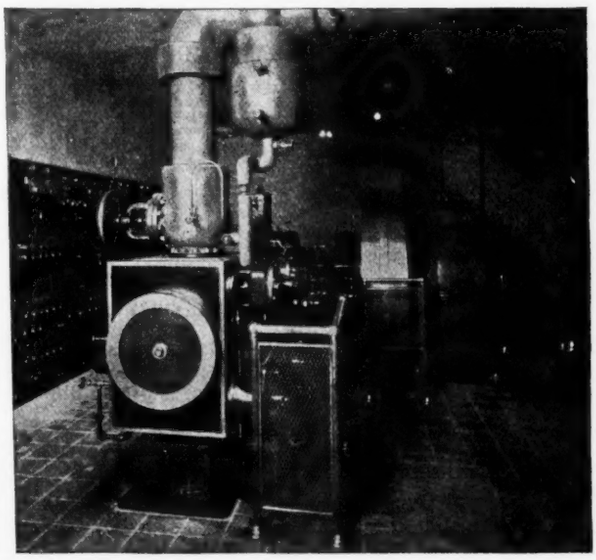
Below—San Antonio Portland Cement Co.'s 2,960-hp. oil-engine plant, San Antonio, Tex. Two 1,000-hp. and two 480-hp. units installed

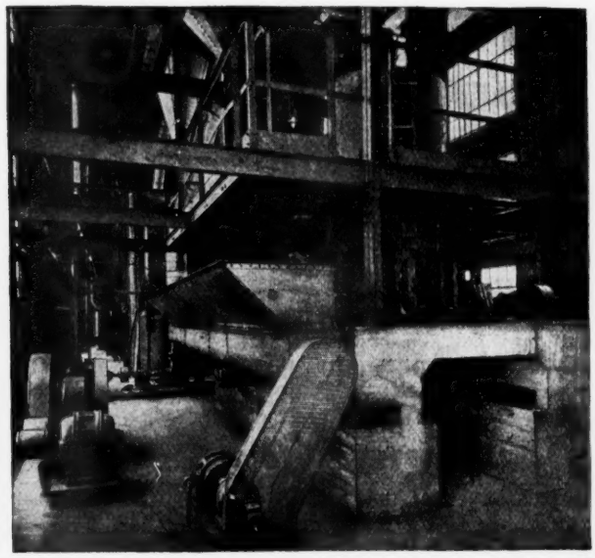




Below, left—Non-releasing 200-kw. Corliss engine installed by Bowery Savings Bank, New York City. Three units installed

Below, right—Pulverized-coal preparation plant for ten 4,270-sq.ft. boilers. Clark Thread Co., Newark, N. J.



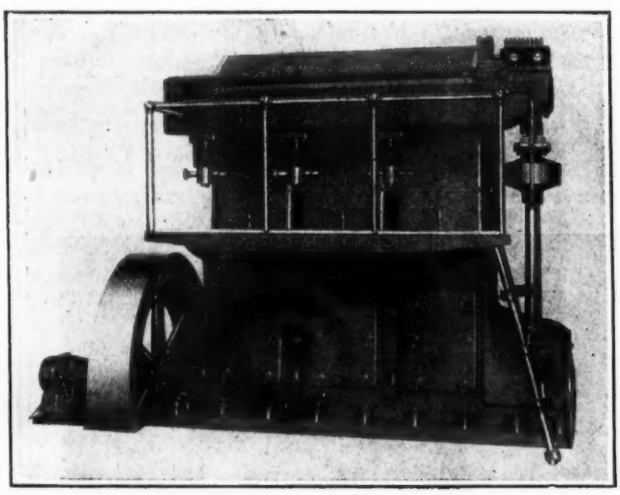


completed a 900-hp. engine, this being a six-cylinder vertical unit, developing 150 hp. per cylinder. Among the new designs are included the Foos engine, built by the Foos Gas Engine Co. This engine uses a plain Diesel combustion cavity and has a novel fuel-injecting system to be described in an early issue of *Power*.

Among the builders of engines of the hot-tube-starting class there has been much activity toward the evolution of these engines into cold-starting units. Fairbanks, Morse & Co. during the year brought out a new vertical oil engine which, while following the general lines of the type "Y," has a compression of 450 lb. per sq.in., making it cold-starting. The new design, in addition, includes refinements in the fuel pumping and injection system.

By reason of cheap gasoline the industrial-machine use of the heavy-oil engine has lagged until recently. Engine builders, especially the Bessemer Gas Engine Co. and the Atlas Imperial Co., have studied the adoption of the solid-injection high-speed engine to locomotive-crane and like practice. At present there are about 50 oil engines installed on these types of machines.

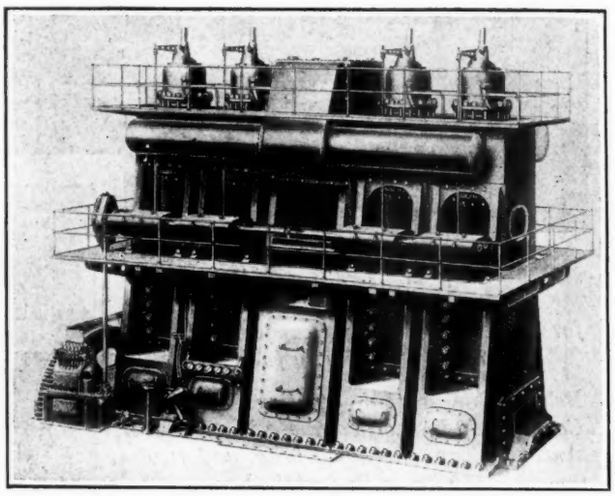
The oil engine has long been desirable as the driving power for locomotives. In Europe many firms have experimented with the combination, but the obstacle has been the transmission apparatus, the gear and the hydraulic system both revealing disheartening faults. In this country the Ingersoll-Rand Co., working in conjunction with the General Electric Co. and the American Locomotive Works, has developed an oil-engine locomotive that has overcome the faults mentioned. This present machine is of only 300 hp., making it adaptable for such light service as switching and branch-line work, but it is only a matter of weeks or months until a multiple-engine locomotive of 1,200 to 1,600 hp. will be evolved. Possessing, through the type of generator and motors used, a high starting torque without engine overloading, the design will undoubtedly be widely adopted.



Foos solid-injection oil engine

The sales of air-injection and solid-injection engines were between 130,000 and 140,000 hp.; the semi-Diesels approximated 80,000 hp.

Oil prices have not fluctuated seriously or unreasonably, but there is an uneasiness that has had its influence in determining the purchase of oil engines. For some unexplained reason governmental officials are prone to announce at various times that the oil supply is failing. Some fifteen years ago the doom of petroleum was predicted to take place within seven years. Fortunately, the prophecy, as do so many, failed to materialize. After a brief period of security the same fate was repronounced and recently a similar warning has been given out. These acts tend to disturb oil-engine users, and unless there be more evidence than so far produced, such public utterances are indefensible. While it is concededly of importance that the waste attending the present drilling and handling of oil wells be eliminated, argument should be based on grounds other than an immediate failure of the petroleum supply. How long the supply underground will last no one knows, nor can any geologist safely define the limits of the oil-bearing sand area.



Worthington double-acting two-stroke-cycle Diesel

Steam Engines Favored in Many Industries

The steam engine possesses certain characteristics of such advantage that even though steam turbines cost far less, the reciprocating machine is still favored in many industries and during the past year over 85,000 hp. of main generating units have been installed, exclusive of small engines for stoker and like drives.

Little change has been registered in design. Probably the most important event was the public announcement of the tests made on the Prosser engine having a steam-jacketed cylinder and a steam-heated piston. This machine, which is a counterflow built by the Chandler & Taylor Co., on test gave results surprisingly good in view of the small cylinder used.

Among the unaflow engine builders business has been good, about 60,000 hp. having been sold by the Stumpf licensees. The most interesting of the new devices is the hydraulic valve gear developed by the Chuse Engine Co.

In unit capacity the steam engine apparently is recovering some ground lost in previous years to the turbine. Engines of 1,500 to 2,000 hp. are being purchased, and the adoption of bleeding devices permits the steam engines to be used at a high economy in mills needing process steam.

Advances in the Refrigerating Art

DESIGNS of refrigerating machinery experienced but slight changes during the past year. The types of compressors remain as heretofore, with a tendency shown for a reversion to the single-acting machine for plants operating with ordinary pressure ratios. Compressor drives are almost exclusively electric motors and oil engines, the former going into probably 75 per cent of the plants installed during the year. This will continue to be the case as long as electric rates for refrigerating plants are held as low as at present.

The difficulty of starting synchronous motors under the compressor load has led to the development of a starting panel whereby the several steps required to be taken before the motor can be synchronized and the load thrown on, are done automatically.

The evaporating portion of the refrigerating plant has been more or less neglected and in past years had not shown the same improvement as the rest of the apparatus. Last year more attention was paid the evaporating coils. Among new designs is one in which the coils are operated flooded and the excess liquid slopping over is caught by an accumulator and returned to the high-pressure side by means of a pump. Thermally, this involves a slight loss, but is of advantage to the operator in that the expansion cock may be left at a predetermined opening, allowing the rate of flow into the coil to be constant regardless of the amount of slopover.

The output of small refrigerating units has assumed startling proportions. The sale of ice to butchers, restaurants, etc., has been replaced by the installation of refrigerating machines of from 500-lb. to 2-ton capacity. Of more serious concern to the manufacturers of ice is the rapid development of household machines. A few years ago these had proved so unsatisfactory that their field seemed to be at the vanishing point. The investment of large capital permitted changes to design and in method of sales to such an extent that thousands are being sold every year. Several cities have as many as 10,000 such units in use in homes and apartment houses.

The household machine has a high load factor, and its sale has been encouraged by central stations, many lighting companies installing the machines and supplying repair service at a low cost.

In view of the widespread acceptance of the household machine as possessing advantages over ice as a cooling medium, there are indications that the refrigerating industry will ultimately become one devoted to cold storage and that the manufacture of ice will become a very minor part of the business.

Engineering Research and Society Activities

THE biggest thing of the year was the World Power Conference and the accompanying mechanical exposition held during the summer at Wembley, England. Initiated by the British Electrical and Allied Manufacturers Association in co-operation with technical and scientific societies throughout the world, the primary object was to consider how the water power and fuel resources of the world might be used most advantageously. In all, 480 papers, each on some phase of this general subject, were presented by the best-informed men in the engineering profession on their respective topics. From a strictly technical point of view it has been said that the papers did not disclose much that was not already known in well-informed circles, but they did give a better understanding of how the different nations are handling the development of their natural resources of fuel and water power and the regulative policies employed. The conference also afforded the opportunity for an intimate exchange of ideas between experts from all parts of the world.

On this side of the Atlantic the third annual power show held recently in New York gave an excellent picture of recent developments in American practice. Devices and equipment coupled with higher pressures, powdered coal, stoker development, air preheating, auxiliary drives, valves, instruments, etc., were to be seen. In fact the display, the largest in the history of the show, was a liberal education to the engineer having interest in the power plant.

During the summer the American Engineering Standards Committee announced its approval as "tentative American standards" the A.S.T.M. specifications for welded and seamless steel pipe and welded wrought-iron pipe, the tentative safety code for laundries, and the A.S.M.E. revised standard for cast-iron flanged pipe and fittings for 125-lb. pressure. Consideration is being given to the standards for steel flanges and flanged fittings for pressures ranging from 200 to 900 lb., and a final steam temperature of 750 deg. F.

A broad investigation of the subject of heat transfer is the momentous task undertaken by the National Research Council. The first step will be a critical study and digest of all the work done to date on the subject, separating the chaff from the wheat and in this way insuring the engineering profession of reliable guidance on this matter.

On the various Power Test Codes being prepared by the American Society of Mechanical Engineers good progress has been made. Those available in pamphlet form are "General Instructions," "Reciprocating Steam Engines," "Hydraulic Power Plants," "Stationary Steam Boilers," "Feed-Water Heaters" and "Internal Combustion Engines." That on evaporating apparatus will be ready in the near future. In addition codes in tentative form are now ready on steam turbines, locomotives, centrifugal and rotary pumps and instrument and apparatus tests for condenser leakage.

A preliminary report on the standardization of shafting has been completed. The special research committee on ball-bearing metals is out to raise a fund of $50,000 to obtain a specialist for five years who will prosecute energetically research in this field either at

the Bureau of Standards in Washington or another laboratory where conditions are favorable. Enlargement of the Boiler Code to cover boilers of high pressures, 600, 900 and 1,200 lb., is now being agitated. The present Code does not cover these pressures, so that the desirability of the extension is evident.

In the steam research work sponsored by the Society and being conducted by the Bureau of Standards, Harvard University and Massachusetts Institute of Technology, progress is reported. The design, construction and testing of the experimental apparatus is nearing completion. It will be recalled that the final data will be incorporated into new steam tables which from the new point of accuracy, range and completeness should excel all existing tabulations on the properties of steam.

A tentative code on blower and exhaust systems by the National Fire Protection Association is now ready, and standard specifications for condenser tubes and ferrule stock have been considered by the Division of Simplified Practice, United States Department of Commerce. Acting upon the suggestion of this same body, the American Boiler Manufacturers Association is now at work simplifying and standardizing the return-tubular boiler. Also an extensive program of research being carried on by the Bureau of Mines on fuels and their burning and many other subjects including refractories, is continuing to prove of inestimable value to the engineering field.

Legislation along engineering lines was not particularly active during the year. The American Uniform Boiler Law Society reported that it had been found advisable to concentrate efforts in strengthening the present departments of the code states, rather than making a special drive to bring new states into the fold. The State of Washington, however, was added to the list of code states. In reply to inquiries sent out bu the Society to the boiler inspection departments of the states and cities that had adopted the 1918 edition of the A.S.M.E. Boiler Code, as to whether they had adopted, would adopt or would accept the 1924 revised edition of the Code, favorable replies were received from 20 states and territories, including the District of Columbia and Panama Canal Zone, and from 15 cities.

Honor Roll for 1924

The highest honor bestowed by the engineering profession in this country, the John Fritz Gold Medal, was awarded for 1924 to Ambrose Swasey, engineer, philanthropist and manufacturer, of Cleveland. According to the announcement the award was made "for the building of great telescopes, the founding of the Engineering Foundation, and the invention and manufacture of fine machine tools, precision instruments and military and naval range finders."

Prof. Elihu Thompson was the first American to receive the Lord Kelvin gold medal. It was presented at the Kelvin Centenary Celebration, held in connection with the World Power Conference at Wembley, London, the award being made by British and American engineering societies acting jointly, for excellence in original research work in engineering.

An event of the year was the unveiling of the memorial tablet erected to the memory of Captain John Ericsson, designer and builder of the "Monitor," and to John A. Griswold, Cornelius S. Bushnell and J. F. Winslow, whose financial and technical aid helped Ericsson greatly in the evolution of his plans.

First presentation of the new Holley Medal of the American Society of Mechanical Engineers was made to Hjalmar Gotfried Carlson, of Worcester, Mass., "for his inventions and processes which made possible the timely production of drawn steel booster castings for artillery ammunition." This is a gold medal for great achievement endowed by George I. Rockwood, vice-president and life member of the Society, which is awarded only "in those rare cases where an individual has succeeded by the exercise of his genius and character in powerfully assisting the fortunes of our country or the general engineering progress of the world."

As a memorial to Dr. Charles P. Steinmetz, who died Nov. 18, 1923, a fund of $25,000 was appropriated by the General Electric Co. The income will be used to provide four scholarships annually to Union College, where Doctor Steinmetz was a professor.

In the will of the late Benjamin G. Lamme, former chief engineer of the Westinghouse Electric & Mfg. Co., a trust fund of $15,000 was set aside to provide scholarships for the two most capable students in electrical and mechanical engineering respectively at Ohio State University. Three medal awards also are provided for in the will. A fund of $6,000 was established for gold medals to be awarded annually to graduates of one of the technical departments of the University for meritorious achievements in engineering or technical arts. Two other funds of the same amount were created to recognize the accomplishments of technical teachers and of members of the American Institute of Electrical Engineers.

Honor of leadership in the various societies and associations closely allied to *Power's* field was conferred by the following presidential selections:

Society	President
American Engineering Council	James Hartness
American Society of Mechanical Engineers	Dr. William F. Durand
American Institute of Electrical Engineers	Farley Osgood
Association of Iron and Steel Electrical Engineers	A. C. Cummings
American Society of Refrigerating Engineers	Van R. Greene
American Society of Heating and Ventilating Engineers	Homer Addams
National Electric Light Association	Franklin T. Griffith
National Association of Stationary Engineers	Dudley G. Kimball
National Association of Practical Refrigerating Engineers	Erle Ormsby
National District Heating Association	O. W. Kastens
American Order of Steam Engineers	Charles T. Burger
American Boiler Manufacturers Association	E. R. Fish
Stoker Manufacturers' Association	W. H. Rea

Necrology

With the year an unusual number of men prominent in the engineering field passed to the great beyond. Among them may be mentioned such outstanding characters as Wilhelm Schmidt, of Germany, a pioneer in the art of steam superheating and the use of higher pressures; Alfred Cotton, research engineer of the Heine Boiler Co.; Henry Mallison Byllesby, nationally known promoter of public utilities; Benjamin B. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Co.; Dr. Charles P. Steinmetz, noted electrical engineer; Wilfred Campbell, of the General Electric Co., famed for his investigation of the axial vibration of steam-turbine disk wheels; George H. Diman, of Lawrence, Mass., one of the men who had a share in laying the foundation of the power industry in America; Dr. Bruno V. Nordberg, founder of the company bearing his name and a steam engineer pre-eminent in the period in which he lived; John Lyell Harper, chief engineer of the Niagara Falls Power Co.; and John Everett Bell, consulting specialist on steam-boiler work and testing.

Blowing Down a Boiler Through the Steam Nozzle

IF ONE were to accuse the average boiler-room operator of blowing down his boilers through the steam nozzle he would take it as a good joke. Yet, for the great majority of power-plants, there would be more truth than fiction in such an accusation.

Blowing down a boiler might be defined broadly as a process of removing concentrated impurities that entered in diluted form. According to the first principles of arithmetic the impurities removed from a boiler over a long period must equal those brought in by the feed water.

Neglecting the direct removal of scale during the periodic cleanings, blow-down (according to the broad definition just given) is the only method of removing these impurities. Therefore, if the concentration of impurities in the feed water is ten grains per gallon and it is desired to maintain a concentration of five hundred grains per gallon in the boiler, the removal by blow-down of 0.02 gallon of water for every gallon fed will take away ten grains of impurities for every ten supplied and thus maintain the given concentration. This blow-down amounts to two per cent.

As defined here, the blow-down includes any water removed from the boiler, whether through the blowoff connection or not. A boiler that produces ninety-nine per cent dry steam at the drum outlet is doing exceptionally well. Assuming that the moisture in the steam has the same concentration of impurities as the water blown down to the blowoff connection, such a boiler would need to have a blow-down of only one per cent through the normal outlet in order to have an actual blow-down of two per cent and maintain the concentration above mentioned. In such a case only one-half of the impurities supplied in the boiler-feed would pass out through the blowoff connection, the other half passing off with the steam.

Thus it is clear that the "blowing down" of boilers through the steam nozzle is not a freak condition, but one of almost universal occurrence. The reasons for this and its bearing on power-plant economics are ably covered by B. W. Andrews in a paper printed on page 37 of this issue.

Plenty of Room for Improvement

THE major portion of this issue is devoted to a review of developments in the power field during the last twelve months. Although no radical changes can be reported over those inaugurated in 1923, the year just past is not without its spectacular features, for it has seen the successful culmination of a number of the innovations started in previous years.

Looking back over the history of power-plant development, it will be found that progress has been made by gradual changes rather than by any abrupt departures from established practice. The most radical change probably took place at the beginning of this century, when the steam engine had been developed to about its limit and the steam turbine was adopted. This development removed the barriers in steam-plant development and placed the limits so far in advance that they have not been reached, twenty-five years later.

During this period there has been a gradual increase in the size of turbines, from 5,000 kilowatts in 1903, which was the first turbine comparable with the largest reciprocating-engine driven unit, to 60,000 kilowatts in a single unit in 1924. This development has been accompanied by a gradual increase in steam pressures and temperatures, from about 175 pounds and 375 degrees F. to 600 pounds and 750 degrees F. Along with other practices that have been adopted, these changes have resulted in cutting the coal consumption per kilowatt-hour by considerably more than one-half.

An improvement in over-all plant thermal efficiency as indicated by these figures is an enviable record, but it is only a conversion efficiency of a little over twenty per cent from fuel to electricity at the switchboard. Looked at from this angle, the ideal goal is a long way off and the question may well be asked, What are the prospects for improvement? Figures presented by E. W. Rice before the World Power Conference last summer indicated that future improvements in the efficiency of steam plants are not so promising. For proposed new stations using 100,000-kw. turbines with two reheatings between stages and steam at 1,200 pounds and 725 degrees F. at the throttle, an over-all thermal efficiency of less than twenty-seven per cent might be expected.

An over-all thermal efficiency of twenty-seven per cent is close to that of a good Diesel engine plant or of the binary cycle now being experimented with. These figures would indicate that we are approaching a barrier similar to that which existed over twenty years ago, when the reciprocating engine had about reached the height of its development. There are possibilities of saving in fuel other than going to higher pressures and temperatures than those now proposed for commercial purposes, but these for the most part are refinements of the conversion cycle rather than any radical change that would open up a new field of development, such as occurred when the steam turbine was adopted.

Although efficiency limits of steam plants may not be very far in advance of what is in sight at the present time, there is a vast opportunity for improving the efficiency of steam power plants in general. In 1923, as shown by the Geological Survey, the average large generating plant turned out a kilowatt-hour on 2.4 pounds of coal. This is nearly double the amount required by some of the leading stations now in operation and nearly three times that required by the future proposed stations. If in the next twenty years power-plant engineers succeed in cutting the coal consumption in

half per unit of power, they will have accomplished a work comparable with that of the last twenty even though it may not be accompanied with the spectacular features of the last two decades.

The Limits of Boiler Efficiency

ONE of the most impressive developments in large power-house operation is the great increase in boiler efficiency within the last few years. The principles underlying successful furnace operation have been known for years. Yet it has only been within the last seven or eight years that a serious attempt has been made to secure the highest efficiency. The primary cause of this advance in the art may be said to be the late World War. High prices of fuel and the need of high ratings to carry increasing loads made engineers study their boiler-room problems seriously and induced them to try out new ideas and new methods of boiler-room operation.

The successful application of powdered coal to boiler furnaces was also a contributing factor in this awakening. The high efficiencies so easily obtained by this means caused greater development in stokers than had taken place in many previous years.

The installation of air preheaters and high-pressure economizers is also increasing, and their use tends to enhance the efficiency of the boiler plant.

Some interesting boiler performances have been recorded. A recent announcement gave the boiler, superheater and economizer efficiency during steaming hours at the Lakeside station at Milwaukee as 91.64 per cent for the whole month of November. This in itself is a remarkable performance for the pioneer powdered-coal central station. A recent announcement states that 93 per cent combined efficiency is expected of the boiler plant of the new Richmond station of the Philadelphia Electric Company, where stokers will be installed.

It is pertinent to ask what is the highest efficiency that one may expect from a boiler plant. Our recognized standard for stating the heat value of coal is that given by the bomb calorimeter. This heat value includes the latent heat of the moisture that is formed by the combustion of the hydrogen in the coal. Such latent heat is made available by the condensation of this moisture within the bomb. The heat value of the fuel found in this way is the denominator of our expression for boiler efficiency.

In practice it is not desirable or practicable to reduce the temperature of the flue gases below their dew point so that the moisture resulting from the combustion of the hydrogen in the coal may be condensed out and the latent heat thereby recovered. This unavailable latent heat is therefore one of the unrecoverable losses in boiler operation and with bituminous coals will range from 4 to 5.5 per cent. Radiation cannot entirely be prevented, and this may be taken for an ideal case as half of one per cent. The theoretically highest boiler efficiency that one may therefore expect after deducting these unpreventable losses would be from 94 to 95.5 per cent. These are significant figures since they indicate that the margins for further saving over the Lakeside and Richmond boiler performances are not large. In fact, it may be said that these are nearly the commercial limit that may be expected of boiler plants as now designed.

Have we therefore reached the practical limit of boiler-room performance? Can no further savings be effected from that source? If this is so, where must our engineers turn next to further improve the efficiency of power generation from steam? Or must our attention be turned to other methods of power generation and, if so, which deserve study? The Diesel engine is the only other promising machine today. What will develop tomorrow?

Non-Corrosive Turbine Blades

IT IS largely the practice in this country to equip central-station turbines with alloy-steel blades in the low-pressure areas. It is somewhat paradoxical that steel, being to some extent corrosive, should be employed in the exhaust region, although material more resistant to corrosion, such as Monel metal or bronze is much utilized for the higher-pressure vanes where water is either absent or encountered to a much less extent.

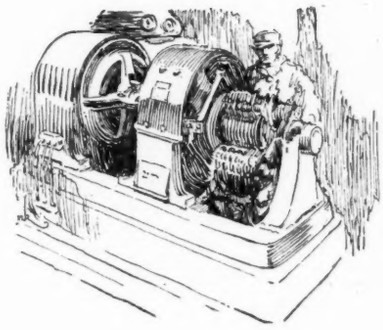
Large units in this country are now of such capacities that the exhaust blading is worked close to the safe limit with regard to physical properties. The necessity for passing such comparatively large volumes of steam has resulted in blades whose lengths, in many instances, are limited by the strength of materials available. In order to meet this requirement, alloy steel frequently employing a definite percentage of nickel, is the logical material from a commercial point of view.

Steels with non-corrosive properties have been developed, whose strengths are practically on an equality with that now employed for large blades. There are, however, three objections, one or more of which are encountered in many such non-corrosive steels, namely, poor workableness, non-uniformity and cost. In the first place, it has been quite the general experience that processes of manufacture, which usually include forging, are carried on with great difficulty in non-corrosive steel on account of the comparative hardness. Some steels whose properties are otherwise satisfactory, have been found difficult of machining.

It also appears that strength, elasticity and other qualities sometimes exist in varying degrees. Chromium is employed to a large extent in many familiar non-corrosive steels, in comparatively formidable proportions. Although strength and resistance to corrosion may be imparted by this element as an alloy, it also affects considerably the properties of the composition with respect to heat treatment and tempering. Chromium, for instance, is much employed in the composition of air-hardening tool steel. Non-uniformity in strength has at times been noted with some steels of this type. A long turbine blade may thus test at radically different strength values for different parts, and brittleness may appear in spots as an objectionable characteristic, resulting from improper heat treatment.

Non-corrosive steel is reported to have been successfully developed which is satisfactory in regard to the obtaining of physical properties, being also comparatively easy to machine, which, however, has not been adopted to a significant extent on account of its cost. Highly non-corrosive steels could be used without difficulty in the higher pressure ranges of the turbines where vanes are shorter and requirements for physical properties not so severe. The element of cost, however, here again becomes prohibitive, so that the cheaper nonferrous alloys, of which nickel is frequently a characteristic element, are as a rule more desirable commercially.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. Three prominent operating engineers have been invited to act as judges. The winners will be announced the succeeding month.

Burning Heavy Fuel in Oil Engines

The question of the advisability of burning "heavy" fuel in oil engines comes up from time to time, and there still exists a certain amount of confusion in the minds of some owners and prospective owners, their engineering staffs and operating engineers, of this type of engine, as to whether it can be done successfully and what results may be obtained.

It would be well at the start to define the meaning of the word "heavy" as it is used when referring to fuel oil. At best it is a very indefinite description of fuels placed on the market for use in oil engines. These are generally a byproduct of oil refineries, and the heat value, viscosity and weight are governed somewhat by chance, for the principal products must be the same regardless of what the raw product may be before it is put through the refining process.

Light fuel, when referring to oil-engine fuel, does not have the definite meaning that gasoline has. Therefore, we have no assurance that 35 deg. Baumé describes a better grade of fuel than does 20 deg. Baumé. For this reason the latter may prove to be better adapted to the use of the general run of oil engines than the former. Such has been my observation in a number of instances.

Although one oil engine may work better on a certain comparatively heavy yet good quality of fuel than it does on another lighter yet poorer quality, this does not mean that such will be the case with all engines. For an engine builder may conduct all experiments and test runs with a very light grade of fuel, produce and adjust atomizing devices accordingly and turn out an engine that will not use a heavier product. This would be an unwise procedure, for it is possible to provide oil engines with atomizing devices that will bring about complete combustion of any fuel that does not contain noncombustible substances such as will be discussed later.

Fuels such as I have thus far referred to come under the commercial heading of "Diesel Fuel," but are sometimes classified as "Gas Oils." Commercial "Boiler Fuel" is another matter. The fact that it is heavier and at the same time lower in price does not signify that fuel is always governed in price by specific gravity. Generally, this crude oil is unsuited to manufacturing purposes.

Extensive experiments have been made with the use of boiler fuels by a number of prominent oil-engine manufacturers. Results have been discouraging and most of them are offering no encouragement to oil-engine owners who would like to take advantage of the lower price.

It is remarkable how our views may change. About three years ago, when I first started experimenting with boiler fuel, I was very enthusiastic about its use in oil engines. A year later I became convinced that it was not worth while. At this time I was employed by a large oil company operating motor vessels equipped with a thoroughly dependable and prominent make of four-stroke-cycle Diesels. Upon the recommendation of the engine builder we took up the use of boiler fuel, not so much with a view to making a saving in the cost of operation as to convince ourselves as to the advisability of using it.

It was a year of extensive experimenting, during the first part of which we were very optimistic, but later we knew that boiler fuel was not economical and that nothing but a commercial grade of "Diesel Fuel" could be used successfully.

While the experiments were very costly, more especially in repair bills and delays, they were at the same time very interesting. The only extra equipment used was a heating system with which any temperature could be maintained on the fuel going to the engine.

The procedure was to mix Mexican crude with the refinery byproduct, lowering the grade somewhat each voyage until it had gone from 26 to 14 deg. Baumé. The light oil was clean and low in sulphur content, while the 14 deg. oil ran as high as 1 per cent bottom settlings and water and 3½ per cent sulphur. At the end of six months we were using Mexican tops undiluted with the refined product.

At this point results became almost disastrous. The vessel upon which I was then chief engineer was in the Transatlantic trade, and we were carrying nothing in the fuel tanks but this low-grade fuel. There being no good fuel to fall back upon, we had to complete the first voyage, but the results were not satisfactory, and we, therefore, tried the same trick over again on the next voyage.

It was found that with a sufficient amount of high-grade fuel mixed with the Mexican crude good atomization and combustion could be maintained and the noncombustible substances in it would be left in a state so dry that they would be almost completely expelled from the cylinders with the exhaust gases.

Without the high-grade fuel present, atomization and combustion were not so good and the noncombustible substances were not left dry within the cylinders nor

were they so completely expelled with the gases. The sticky substances deposited within the cylinders interfered with lubrication and caused the rings to stick. This allowed the hot gases to escape by the pistons, further spoiling the cylinder lubrication. Pistons dragged, cylinders wore, the engine labored, power losses were great, heat stresses became very pronounced and cracked cylinder heads resulted.

To make the situation worse, a leak developed in a fuel tank, and the sea water which came in went into suspension in the heavy fuel about as rapidly as it would go into a dry sponge. Salt was deposited within the cylinders and on the exhaust valves, and no amount of settling and heat treatment of the fuel would cause it to drop the water. The ship had to come home under these conditions.

Like all large companies the owners were very persistent. We went back to a mixture and having the question of what we could burn and what we could not burn well in hand, we confined our observations to other matters of importance such as cylinder wear and lubricating-oil consumption. By this time we knew that the Mexican crude carried certain noncombustible substances and felt that although they were not leaving noticeable deposits within the cylinders, a portion of the ash must be clinging to the oily surfaces of the cylinders. This proved to be the case and excessive cylinder wear resulted. Although the cylinder lubrication did not mount to any great extent, the oil to the bearings and cranks became very foul, necessitating frequent renewals and crankcase cleanings. All the dirty oil from the pistons dropped into the crankcase, which was used as an oil reservoir and drip pan.

Toward the end of the year, while burning about 20 per cent of 26 deg. oil mixed with 80 per cent of 14 deg. Baumé fuel, we had another tank leak develop, which of course had nothing to do with the use of good fuel but proved to be the last straw. The sea water leaking into the fuel tank rapidly went into suspension, and it developed that although the light fuel present helped combustion to a great extent, it was of no use in helping to eliminate water. We went through the same experience of defective operation as before.

The owners gave up in disgust. We went back to a good grade of fuel and are sticking to it. If anyone should ask the ship owners about the engine builder's claim that his engine could burn boiler fuel, they would reply that it could be done but they had found it unprofitable.

One of the very interesting outcomes of the whole thing is that we learned that almost any commercial grade of Diesel fuel can be used successfully in almost any oil engine, provided a means of heating it is employed and if it does not fall below 20 deg. Baumé at a normal temperature of 60 deg. F. Of course this does not take into account freak engines or engines on which all the shop tests and experiments have been run with a fuel above 30 deg. or with kerosene.

Although the discussion has been confined to the experiences of one company with one ship and one make of engine, past experience has taught me that oil engines large and small, two-stroke-cycle, four-stroke-cycle, surface-ignition or Diesel, airless-injection or air-atomization, will work successfully on any fuel of better than 20 deg. Baumé with but little change in the equipment sent out by the builder. If any change is found necessary, the engine builder should be consulted.

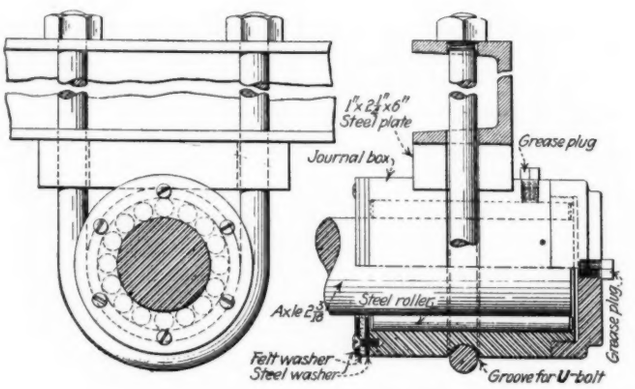
Woodbury, N. J. A. B. NEWELL.

How Bearings and Axles of Coal Larry Were Changed to Compensate for Offset in Track

In our plant we have two motor-driven coal larries to supply the boilers, which gave considerable trouble when first put in use.

On one side of the boiler room the track is straight, but on the other side there is an offset in the track of about three feet. Making the double curves of this offset, which are of rather small radius, caused a twisting or cramping strain on the axles, which apparently crystallized the metal, causing them to break.

In order to overcome this trouble we equipped the larries with new axles, having one wheel keyed to the axle and the other free to revolve. In the event that we should not get traction enough with one wheel the



Construction of roller bearing and method of attaching to larry frame

keyways were made long enough to allow extra sprockets to be keyed to the axles and have both axles as drivers. However, on trying out the larries we found that there was sufficient traction with the one wheel.

As the larries came equipped with cast-iron journal boxes having open ends which permitted the coal dust and grit to get in, these boxes were replaced with roller bearings made as shown in the illustration. Making the roller bearings entailed considerable work. Owing to the fact that it takes considerable time to get iron castings here, we were compelled to use 4-in. round bar steel for the housing. We did not wish to weaken the frame of the car, so we were limited as to the over-all size, and it was necessary to make them as near the size of the old ones as possible. The bearings were clamped to the frame of the larry with U-bolts as shown.

The brake beams were also a source of annoyance, as they were directly in the way of the discharge of the coal and close to the rails. If the boiler hoppers were heaped up, the brake beams scraped the coal off the hoppers and kept the boiler-room floor in a dirty condition. To obviate this, we had new brake beams of ½x2-in. flat steel forged in the form of an inverted U carrying the arch well above the coal discharge. Since only one of the wheels was keyed to the axle, it was necessary to change the connecting link from the foot brake to the brake beam, to the side of the larry, where it would exert a direct pull on the brake shoe on that wheel. These changes proved to be well worth while.

Logan, W. Va. E. GEORGE.

Comments from Readers

Electric Heating

I was much interested in the article on page 986 of the Dec. 16, 1924, issue of *Power* called "Electric Heat Fallacy." The article is, of course, quite correct, and the statements in the daily press to the effect that we are at the threshold of general electric heating are quite misleading.

Electric heating is not, however, so impossible a proposition as a casual reading of the article might lead one to believe. If a man were to build a house, with electric heating in view, he would use special walls and windows at a very moderate increase in cost, and thus cut down the heating requirements greatly. If the energy of electricity were used merely in resistance elements to heat air from a temperature of 30 deg. F. to a temperature of 100 deg. F. for use in the home, it would perhaps take very many kilowatt-hours. However, if the energy of the electricity, instead of being used in a resistance element, were used in such a way that for every 5 lb. of air taken into a suitable apparatus, 1 lb. would be heated to 100 deg. F. and 4 lb. cooled to 15 deg. F., the warm air at 100 deg. F. being used for heating purposes, and the cold air at 15 deg. F. being rejected, not nearly so much energy would be required. It is in the realms of possibility that some such apparatus might be developed. Witness, for example, the home refrigerators now in use.

Lord Kelvin put the case somewhat like this: Suppose we have a large garden to be watered and a small reservoir of water at a level of 1,000 ft. above the garden. There is also a large reservoir about 10 ft. below the level of the garden. If the water from the highly elevated reservoir were used to water the garden direct, it would not be nearly sufficient. If, however, in some way this high level water could be used to bring up the low-level water, the garden could be irrigated to the desired degree.

A. H. PUGH.

Cincinnati, Ohio.

Welded Pipe Installations

The editorials in the Nov. 18 and 25, 1924, issues, on welding of pipe joints, are worthy of study on the part of power-plant engineers. Unfortunately, most engineers leave work of this kind to the repair man or shop construction engineer, who, when the job is completed, thinks no more of the improvement as far as the engineering public is concerned until he is again called to make repairs. The chief engineer is usually too busy to write a description of any particular repair, and the operating assistants seem to care little of the mechanical work or are too busy with the routine work of the plant to give much thought to the details involved.

There are many advantages to be gained in the use of welded joints in place of the ordinary flanged type. No bolted gasket pipe joint stands up any too well on the present-day high steam pressures and superheat. In some cases with pressures of 300 lb., which is considered moderate today, the joints were made tight by using annealed $\frac{1}{32}$-in. sheet-copper gaskets coated on each side with a thin mixture of red and white lead. Frequently, two or three trials had to be made before the joints were tight. Previous to the advent of the oxyacetylene torch some engineers advocated brazing the joints, but this was expensive, as the piping had to be heated evenly all around the joint, which made this method impractical for general use.

The most frequent sources of trouble are undoubtedly the small leaks that develop in a gasket or fitting, and owing to the expense or labor involved in replacing the gasket, the leak is allowed to continue until it becomes a nuisance or a source of considerable waste. Whereas, if the joints were welded this leakage would not occur unless the weld cracked. I fully agree with the editor with regard to the Van Stone type of joint but I think this can be improved upon. In some cases the tongue-and-groove flanges are used with V-shaped ground joint contact or with a narrow copper gasket. Where such pipe and fittings are used, no others can be put in without cutting the flat or V-shaped tongue off one flange. The so-called ground joint ball and socket flanges also belong to this class of fittings, and often, when replacing a short nipple or tee, it is necessary to spring the flanges apart from $\frac{1}{2}$ to 1 in. in order to remove the nipple, and then it is not always convenient to get the right flanges to replace.

Further discussion on the use of welded pipe with perhaps some illustrations showing the process of welding the pipe joints would prove of value to *Power* readers.

R. A. CULTRA.

Cambridge, Mass.

Prevention of Accidents in Power Plants

With reference to the "Foreword" in the Nov. 4, 1924, issue, which contains many good and proper words relative to the cause and prevention of accidents, I wish to give some of my views in respect to the elimination of accidents in power stations and industrial plants.

Safety committees should be inaugurated, the members of which should be prompted to direct their thoughts along lines of safety so that by their example and influence others will be induced to follow in the same channel. There should be a place for everything and everything should be kept in its place. If this were practiced methodically, "the number of accidents" would be considerably reduced. The power-plant engineer or supervisor should exercise close supervision in this respect, as many accidents occur from tripping and falling over misplaced material. For this reason employees should not be permitted to throw tools or material on the floor. It requires but a few minutes to see that everything is put in its proper place, and the acquirement of this practice tends greatly to lower the percentage of accidents in the plant.

The effects of carelessness and inattention in indus-

trial plants are far-reaching. Carelessness of employees is considered the most common cause of accidents, being rated by some at about double that due to faulty equipment. A large number of accidents are attributable to the dangerous practice of cleaning and oiling machinery while in motion, also to employees who are not familiar with their machines and work. The remedy is to see that all employees have a working knowledge of machinery and plant equipment and encourage them to perform their duties in a safe and efficient manner. Experience and skill are not only necessary to one's work, but are essential to safety.

A potent factor for avoiding accidents in power plants and factories is proper illumination, and an important adjunct to good illumination is proper interior painting. Ceilings should be whitewashed or painted white, and so should the walls to within six feet of the floor. The lower six feet may be painted a dark red or black, or any good wearing color desired. I might go to much greater length and deal with many risks that are run hourly in power plants and factories by the use of poorly constructed protection guards, improper and defective tools, unsafe scaffolding and ladders, wrong methods in cutting off bolts and rivets, removing guards from machinery for the sake of convenience, wearing loose sleeves around revolving machinery, careless handling and lifting of materials, etc. The remedy is to be constantly on the lookout to see how working conditions can be kept safe and, if possible, made safer.

Many accidents are caused by inattention, carelessness or lack of skill or judgment, and for this reason the training of employees should be given at least as much attention as the installation of protection guards. All that is necessary is to get into the habit of asking ourselves "Is it safe?" before a job is attempted. Self-preservation, which is the first law of Nature, will give the answer instantly. W. ANDREWS.

Manchester, England.

Utilization of Heat Head

I wish to make the following comments upon the article by A. C. Christie in the Dec. 2, 1924 issue, on the subject of "Utilization of Heat Head."

Professor Christie in his article cites several sources of possible loss that he fears might be overlooked owing to a lack of consideration of the proper use of heat head. One of the losses dealt with is that due to the inefficiency of steam-jet air ejectors. It is stated that, after allowing for the bleeding of an amount of heat equivalent to that exhausted by ejectors, sufficient power can be developed to do twice as much work as the ejectors. Although this may be true, it is thought that the other considerations will outweigh this consideration of thermal efficiency.

With but reasonable attention to valve glands and small fittings the air leakage in even the largest surface condensers can be maintained at 5 cu.ft. per minute or less. With this air leakage it will only be found economical to use an amount of ejector capacity requiring approximately 750 lb. of steam. Assuming that the heat in the exhaust of this steam replaces steam bled from the lowest-pressure bleeding stage of a turbine at which the bled steam has a value approximating 30 per cent as great as that of live steam, the equivalent steam required is 0.7×750, which is 525 lb. per hour. Considering the high investment and operating costs of the reciprocating vacuum pump, it will be seen that if there is any saving, it will be very small and will be outweighed by the greater reliability of the ejectors which are not dependent on a source of electrical power.

It is stated that the use of high-pressure evaporators cannot be justified from a consideration of the heat head. It is thought that the same amount of heat head will be required whether the evaporators are operated with high- or with low-pressure steam, since with high-pressure steam supply the vapor will be used to heat feed water at some heat level lower than that of the heat supplied, and since the value of this lower heat level at which the heat in the evaporator water is absorbed can be raised when the value of the supply steam is raised. Since the amount of evaporator surface required for a given amount of makeup will vary almost inversely with the temperature head or heat head between the higher and lower heat levels between which they are to operate, the saving resulting from the reduced heat head should be balanced against the fixed and operating charges on the required extra evaporator capacity, in determining the most economical heat head.

However, the designer does not have a great deal of choice in selecting the heat head for the evaporators, since the bleeding points in modern turbines are fairly well standardized by the turbine manufacturer. In cases where the makeup requirements of a station are not definitely known, evaporators can be arranged so that they can be operated both single and double effect. The evaporators can then be operated single effect only when two-effect operation will not supply sufficient makeup water. This scheme, although involving a slight increase in piping costs, would permit the most economical utilization of the heat head.

Where soot blowers are properly operated, the cost of steam is an exceedingly small item. When it is considered that to secure steam at a pressure high enough to be effective in blowing soot, it would have to be bled from the turbine at a stage where the pressure would not be less than 100 lb. and the value of the steam would be approximately 75 per cent as great as that of live steam, it will be seen that the saving would hardly pay for the investment cost and heat losses in a pipe line from the turbine to the boiler room. In addition the effectiveness of the soot blowing would probably be reduced in the same ratio as the pressure was reduced.

Professor Christie mentions the saving possible by utilizing the heat from boiler blow-down. A small calculation would show that the heat loss from blow-down in a condensing station is a small item. Assuming a makeup of 4 per cent, and that evaporators are not used, it will be necessary to blow off 0.4 per cent of the feed water to keep the concentration in the boiler at ten times the concentration of the makeup water. The heat added to each pound of makeup water to raise it to the temperature of the boiler water will be about 30 per cent of that added to each pound of steam in the boilers. In most cases this heating will be done by low-cost heat from bled steam or from the boiler outlet gases. The equivalent heat loss from blow-down with this percentage of makeup should not exceed one-tenth of one per cent. If evaporators are used and the condenser leakage is kept below 65 per cent, as can be easily done, the loss will be less than two-hundredths of one per cent. It would not seem that the installation of equipment to use the heat would be justified.

New Kensington, Pa. HAROLD EDWARDS.

Pulverized-Coal Boiler Performance, Brunot Island Power Station

The points brought up in W. A. Kemp's letter in the Nov. 25, 1924, issue relative to the article in the Oct. 14, 1924, issue entitled "Pulverized-Coal Boiler Performance, Brunot Island Power Station," have just been brought to my attention upon return to Pittsburgh after several weeks absence.

Several points upon which Mr. Kemp desires further enlightenment are elaborated herewith.

The pulverized-fuel installation at Brunot Island does not represent the latest or most improved type, but was installed early in 1922. Furthermore, the installation was made without raising the boiler and without the utilization of additional building space, and certain compromises in design were necessitated.

In the statement, "Comparatively high efficiency can be attained without the employment of highly skilled operators," the intention was not to infer that the operation of stokers requires more highly skilled attendants, but that with no special talent, training or long experience, pulverized-fuel equipment can be operated efficiently with the aid of standard boiler-control instruments used in most modern boiler rooms. Each type of equipment has potential possibilities, and the same operator can realize these possibilities to a higher degree in the case of pulverized-coal firing.

Experiments with two sizes of superheaters, as well as two types of baffling, were made in order to obtain data which would be of use in future designs. It is conceded that the boiler must, of necessity, have been out of service while these changes were made. The outages, however, were not chargeable to the furnace or firing equipment.

The 1,600 cu.ft. additional furnace volume was obtained by utilizing space normally occupied by the stoker and ashpit. The boiler was not raised, and the volume occupied by the unit remained practically the same. To obtain the same combustion volume on the stoker-fired units, the boiler would have to be raised several feet with consequent extensive building alterations. While an increase in furnace volume would doubtless increase the combustion efficiency of a given stoker, the gain would not be very great.

The manufacturers of pulverized-fuel burning equipment have demanded and obtained large furnace volumes. It is up to the stoker manufacturers to obtain the furnace volume they consider advantageous.

The primary purpose of the air-cooled wall is to preserve the furnace lining, not to obtain preheated air. The use of air-cooled walls reduces the radiation loss slightly, but in our opinion the moderate rise in temperature of the air has little effect on the efficiency. The stoker-fired unit was not equipped with air-cooled walls.

The statement, "Because of the nature of combustion of coal, when in a pulverized form in a furnace, the lack of an appreciable heat storage in the furnace and the ease of control of the feed of both the fuel and the air, the burning of pulverized coal lends itself well to automatic control," was based on observations of automatic control equipment on a pulverized-coal fired boiler. We have no stoker-fired units equipped with automatic control and therefore cannot make the comparison.

The statement in the original article that "the tubes of the pulverized-coal fired boiler are not subjected to the same accumulation that occurs with a stoker-fired furnace," was also based on actual observation. Not only was much less material deposited on the heating surface of the pulverized-coal fired boiler, but the deposit was of such a nature that it could be readily removed with soot blowers. On the other hand, the slag on the stoker-fired boilers is hard, adheres to the tubes and is not easily removed by ordinary soot blowers.

The small accumulation of ash on the tubes of a pulverized-coal fired boiler and the easy removal of the material that does adhere to the tubes, are commonly attributed to the lowered furnace temperatures resulting from the use of water screens. No doubt these conditions result from the character of the material entering the boiler, its physical makeup and temperature.

The opinion has been advanced that the size of the particles of coal and ash entering the boiler has a great deal to do with the nature of the slag deposit. In the case of the pulverized-coal fired unit the coal particles are extremely small and the volatile constituents are readily distilled, leaving a residue of ash or ash and carbon. These small particles easily give up their heat when they enter a cooler zone and solidify, bounding off the tubes when they strike. Moreover, the combustible entering the boiler is in the form of very small spheres of coke, which have a hard texture, preventing their adhering to the boiler tubes.

When larger particles of ash do adhere to the tubes and gradually build out, they do not fuse together to form a hard mass that is difficult to remove, but the growths of ash have a very light bond with the tube and frequently drop off of their own weight.

In the case of the stoker-fired boiler, however, the particles of ash and coal entrained by the gases are comparatively large, as may be readily seen by comparing the cinders discharged from a stoker-fired boiler with the refuse from a pulverized-coal fired boiler. Since the particles of coal leaving the fuel bed are comparatively large, the volatile constituents do not have sufficient time to distill off, hence some of the particles are in a sticky, tarry state when they hit the boiler tubes. They adhere readily to the tubes and continue to give off gas which burns readily in the hotter parts of the boiler. When the deposit has built up sufficiently to insulate the tubes, the burning particles of coal that adhere, continue to burn with such intensity that the ash is fused into a solid mass that is difficult to remove.

The percentage of CO_2 that can be maintained is not entirely a question of the melting point of the brickwork, but is also dependent upon the melting point of the ash in the particular coal burned. A good quality firebrick will withstand ordinary furnace temperature, but it may not withstand the erosive action of molten ash.

Mr. Kemp says: "The percentage of CO_2 maintained is largely a question of the life and maintenance of furnace refractories and has little, if any, bearing on the method of combustion." According to this, if we eliminate the question of refractory maintenance (as is now being done with water-cooled walls) a high-ash, low-fusion-point coal can be burned on an underfeed stoker with as high CO_2 as when burned in pulverized form. This is contrary to our experience with underfeed stokers burning a high-ash coal having a low fusion point.

L. W. HELLER,
Supt. of Power stations,
Duquesne Light Co.
Pittsburgh, Pa.

Questions and Answers

Conducted by

Franklin Van Winkle

Regulating Discharge of Centrifugal Pump

We are about to install a single-action single-stage centrifugal pump driven by an oil engine for raising water from a small stream, with about 18 ft. suction lift and discharge to an open tank about 10 ft. above the pump. The piping will be of the sizes recommended by the manufacturers of the pump. At times there will be insufficient water to supply the full capacity. If we use a valve in the suction pipe partly closed, would that reduce the power required in proportion to the quantity delivered, or would it be more advisable to place a valve in the discharge line? P. H. C.

For good operation it is essential to have a gate valve in the discharge line. This valve should be closed and the pump primed before it is started. When the suction pipe and pump are filled with water and all air expelled, the air cocks should be closed. The pump never should be run unless filled with water. In starting, after the normal speed is obtained, open the discharge gate valve slowly to a point where the desired quantity of water is delivered without reduction of the normal speed or loss of suction water. When the pump is thus operated at reduced capacity by throttling the discharge, the power required will be greater in proportion to delivery than when operated at normal capacity, but the efficiency will be greater and there will be greater uniformity and certainty of operation than from throttling the suction.

Holding Portable Boiler Warm Without Firing

We have two oil-burning boilers of locomotive cranes that we wish to keep warmed up at night when the oil burners are out of use. Would it be practical to supply steam from the main boiler room through the bottom blowoffs of the crane boilers and drain out the water at intervals? S. W. L.

Steam introduced through the bottom blowoffs would cause more or less water hammer, which might be damaging to the crane boilers. A better method would be to keep the boilers warmed by gravity circulation of water from a closed heater supplied with live steam from the main boiler plant. The heater may be of simple construction, such as a ¾-in. steam pipe inside of a 3-in. pipe kept filled with water and placed below the water level carried in the locomotive crane boilers, with the lower part of the water space of the heater connected to the blowoff of the locomotive crane boiler and the upper part of the heater connected a few inches below the lowest water line carried in the crane boilers. The water space of the heater should be provided with a safety valve to relieve expansion of the water when disconnected from the crane boilers, and provision must be made for drainage of the condensate formed in the steam pipe or coil of the heater. Similar arrangements are employed for maintaining a low pressure of steam in fire-engine boilers while held in readiness for duty. For this purpose "pull apart" connections are sometimes made with an ordinary coal-fired hot-water heater. While connected the steam space of the steam boiler is the expansion space for the heater.

Caustic Soda in Boiler Water

Our boiler feed water is taken from a small stream that of late has been polluted by washing water containing large quantities of caustic soda discharged by a tannery. Would not this be a cause of trouble from corrosion of brass valves and other boiler fittings and foaming of the boilers? W. T. B.

Caustic soda alone has slow corrosive action on brass alloys or other metals but, in combination with other ingredients of polluted water, it would be difficult to state what chemical effect the presence of caustic soda would have without knowing the actual composition of the metal and the analysis of the water. The best evidence of corrosive action due to caustic soda alone would be to take one of the corroded valves, flatten and polish a surface about ½ in. in diameter, and apply a concentrated solution of caustic soda to the polished surface. With the surface left to stand moistened for several days, the corrosive effect could be observed. Caustic soda in boiler-feed water will cause foaming, especially in feed waters that are polluted with either vegetable or animal substances. Grease in the water combines with the caustic soda to form a soap which boils up into soap suds.

Work of Raising Water by Suction Lift

Does it take more work to raise water by suction through a height of 15 ft. than to discharge it at the same height, assuming the friction is the same in each case; and what is the formula for suction lifts in pounds per square inch? T. J. H.

When water is raised by suction, the work consists in removing some or all of the pressure of the atmosphere from the surface of the water in the suction pipe, and with the pressure of the atmosphere continuing on the surface of the body of water surrounding the suction pipe, the suction water is pressed up into the suction pipe. In operation, the amount of atmospheric pressure that has to be removed by the pump is the same as the downward pressure of the water in the suction pipe and is just the same as the force exerted by the atmosphere or any other method of forcing the water upward the same height.

Hence the work performed in raising a given quantity of water by suction is the same as the work required for lifting the same quantity by forcing it up through the same height.

For each foot of height the pressure exerted by a

column of water at the temperature of 62 deg. F. is 0.433 lb. per sq.in. The greatest theoretical height to which water can be forced by the pressure of the atmosphere is the atmospheric pressure of the place in square inches divided by 0.433. At sea level where the average pressure of the atmosphere is 14.7 lb. per sq.in., the greatest height of water column that could be balanced by the atmospheric pressure would be 1,417 ÷ 0.344 = about 34 ft.

For any given suction lift the pressure per square inch of atmospheric pressure to be overcome would be given by the formula,

Atmospheric pressure to be removed per sq.in. = *Suction height in ft.* × 0.433

which is the same as

Pounds pressure per sq.in. required to force water = *Height in feet* × 0.433

Effect of Lap Without Changing Eccentric

What will be the effect on the running of a double-eccentric Corliss engine if we give the steam valves the same lap when the wristplate is in the center of its travel as we would give the valves of a single-eccentric Corliss engine? *P. E. M.*

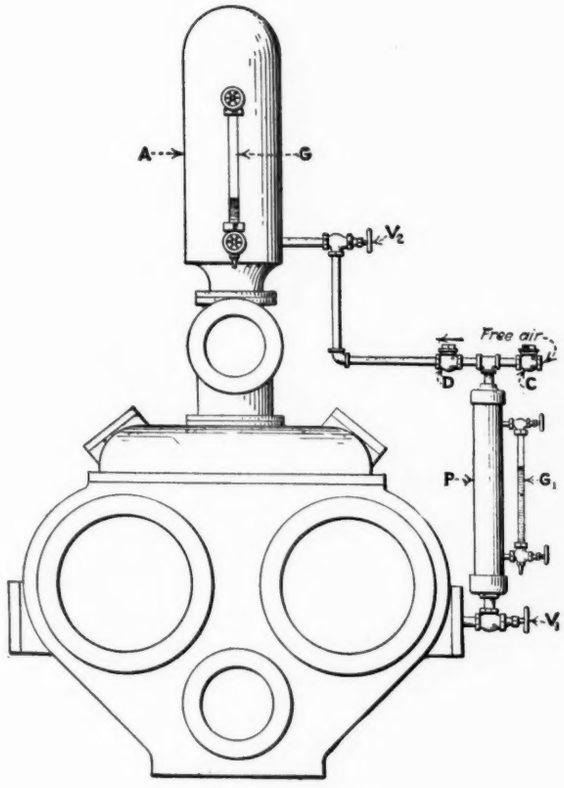
If the steam eccentric of the double-eccentric Corliss engine is set at the same angle with the crank as the single eccentric would be set, and the steam valves have the same lap, then the lead and range of cutoff would be the same. In either single- or double-eccentric Corliss valve gears, the cutoff must take place before the wristplate swings farthest to one side of its central position. If the eccentric in both cases is set at right angles to the crank and the valves have no lap, they would open at the very beginning of the stroke and the greatest range of cutoff would be about one-half stroke. If lap is given to the valve and the eccentric is left at right angles to the crank, the valve would be late in opening. If the valves have positive lap and the eccentric is moved forward of the 90-deg. position for the beginning of the stroke, then the wristplate would stand beyond the central position at the beginning of the stroke, and as less than half stroke of the piston would be required to bring the wristplate farthest to one side of the central position, the cutoff would have to occur before one-half stroke. This is the usual condition found in the valve setting of a single-eccentric Corliss engine, because the eccentric is advanced for the sake of operating the exhaust valves so they will open for release before the end of admission stroke and close to obtain compression before completion of the exhaust stroke.

In the double-eccentric Corliss engine the setting of the steam eccentric is entirely independent of the exhaust. As usually operated, the steam eccentric is set at less than 90 deg. ahead of the crank, so part of the stroke can be accomplished before the wristplate comes up to the central position and more than half stroke is accomplished before the wristplate swings farthest to one side. Then, in order that the valves may open at the beginning of the stroke, they must be set with negative lap; that is, will be open by the time the wristplate comes up to the central position. But if given positive lap, as usual in a single-eccentric engine, the admission would be late, because the valve could not uncover its port until the wristplate would be carried to and beyond the central position.

Maintaining Air Charge in Pump Air Chamber

The occupants of our building are much annoyed by hammering and jarring in the house-service water lines from running of a direct duplex steam pump. The pump is provided with an air chamber that appears to lose its water. What remedy is suggested for the trouble? *G. J.*

The volume of air in an air chamber that is connected on the pressure side of a pump becomes reduced, and soon disappears, from absorption of the air by the water. To keep the air chamber charged, air from a compressor or an air charging device must be provided frequently. The figure illustrates an air charging device that utilizes the varying pressure in one of the



Air-charging device

pump chambers of a duplex pump to compress and force air into the air chamber of the pump.

A small vertical pipe *P* preferably fitted with a glass gage *G* is attached to the side of the pump body and is in communication at its lower end through a stop valve V_1, with the inside of one of the pump chambers. The upper end carries two check valves, *C* and *D*. Check valve *C* is for suction of free air, and check valve *D* communicates, through stop valve V_2, with the pump air chamber. During operation of the pump with valves V_1 and V_2 open, air is drawn through *C* on the suction stroke, and on the discharge stroke this air is compressed and sent over into the air chamber, since the air cannot escape to the atmosphere and the pressure in the pump cylinder is greater than the pressure in the air chamber. On each stroke there is a slight discharge of air into the chamber, and after sufficient air is obtained, as indicated by the glass water gage *F*, the stop valves V_1 and V_2 may be shut off and the operation of this air pump ceases.

A new slant on things observed in and out of the power plant

What Happens and Why?

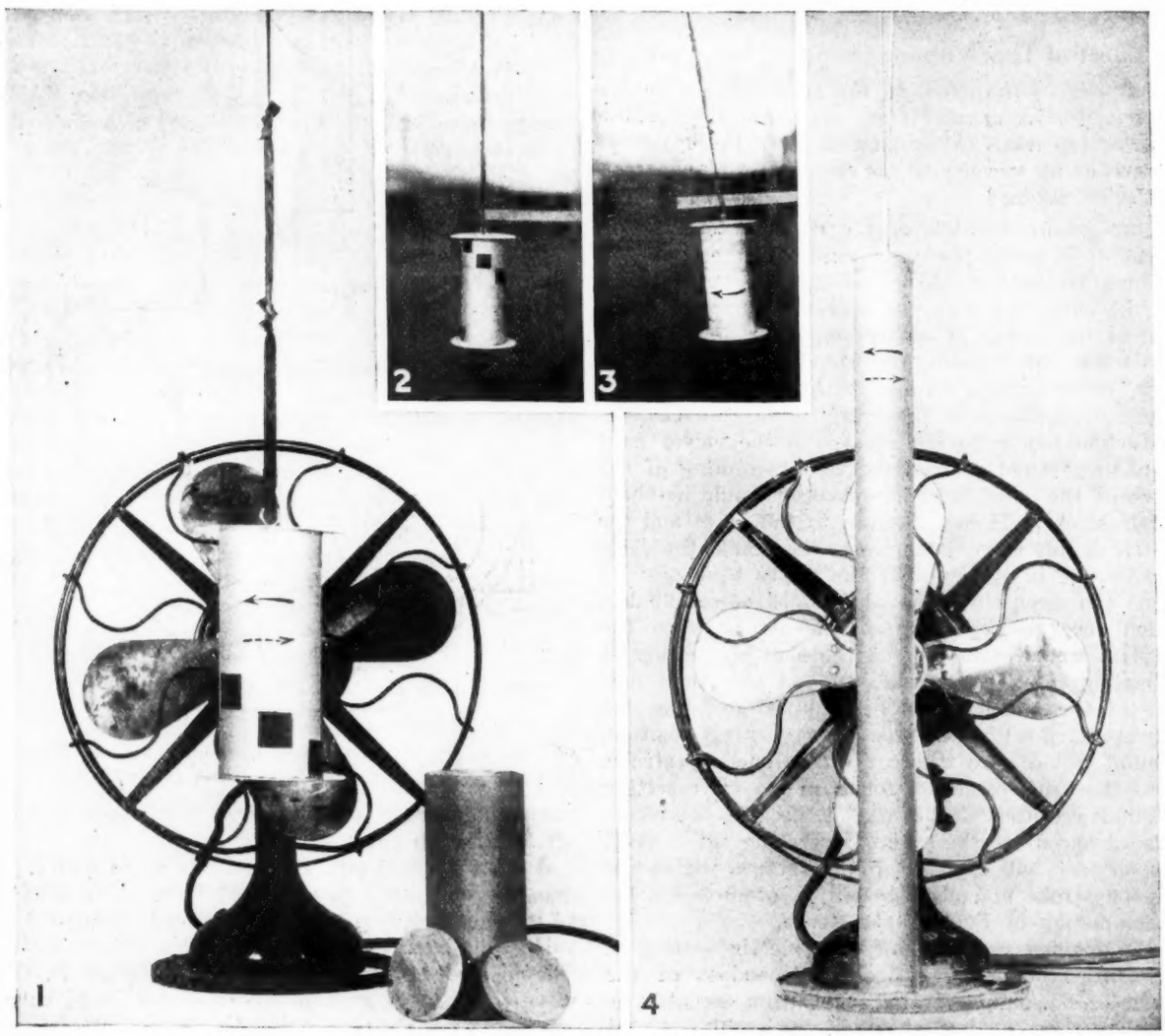
Principle of Flettner's Ship Easily Demonstrated

WHEN the German engineer, Anton Flettner, recently announced the invention of a sailless ship operating on the "Magnus" principle, most engineers felt that the Magnus principle needed as much explanation as the ship. This explanation was forthcoming (see *Power*, Dec. 30, 1924). To boil it all down, Flettner has tested, with reported success, a 600-ton ship equipped with two rotating towers driven by small motors. The towers, which are smooth cylinders, replace about ten times the same projected sail area. As explained in the Dec. 30 issue, the force exerted on the rotating cylinders is approximately at right angles to the direction of the wind, the force being toward that side of the cylinder which is moving *with* the wind. This is the Magnus effect, which explains the curving of baseballs and golf galls and the drift of artillery projectiles.

To demonstrate the truth of the Magnus principle as applied to cylinders, a member of the *Power* staff constructed and tested the models shown in the accompanying photographs. The models and tests were of such a simple nature that they may easily be reproduced by any busy engineer who desires a personal demonstration of the Magnus effect.

Fig. 1 shows the first model cylinder, constructed of the parts shown, which were obtained in the radio department of a five-and-ten-cent store. By twisting the suspending rubber band the cylinder can be rotated rapidly in either direction. With the fan in operation the cylinder will be thrown to the reader's right when it is rotated in the direction of the solid arrow and toward the reader's left when the rotation is in the opposite direction. Figs. 2 and 3 show the same effect in a natural wind blowing toward the reader.

A simpler arrangement is shown in Fig. 4. This is merely a mailing tube with two suspending strings tied to the cap in such a way that twisting the strings causes the tube to rotate. References made to the arrows in Fig. 1 apply here as well, the cylinder swinging toward the side moving with the wind.



Figs. 1 to 4—With the wind coming toward the reader, clockwise rotation of the cylinders as shown by the solid arrows causes them to swing out to the reader's right, or the side of the cylinder moving with the wind

The Physical Side of Concentration in Boilers*

By R. W. ANDREWS
Andrews-Bradshaw Company

Priming and foaming cannot be prevented, nor can boiler concentration; hence the complete purification of steam is a practical necessity.

BY THE physical side of concentration in boilers I mean the *results* from an operating viewpoint after any and all chemical reactions have taken place.

There is considerable confusion regarding the terms "priming" and "foaming." Priming really means the mechanical throwing of droplets of boiler water into the steam. The causes of priming are of course varied, but under a given condition of water analysis, boiler construction, steam space and water level, the degree to which a boiler primes is usually determined by the rate of steam delivery.

Foaming, on the other hand, means the formation of actual bubbles of steam surrounded by a film of water. Foam formation is caused mainly by the association of soluble salts with minutely divided insoluble matter in the boiler water, and experiments have shown that sodium sulphate causes a higher degree of foaming than any other soluble salt. Sodium sulphate is highly soluble and there is no known practical method of getting rid of it. It is also the most common impurity in solution in treated boiler water. Furthermore, the extremely small amount of solid particles necessary to produce foam is always present.

Dry Steam Never Produced

Both priming and foaming result in actual boiler water being carried out of the boiler with the steam. Actually, any boiler under load is continually priming and foaming. If there are any impurities in the boiler water itself, then the water that is carried out with the steam carries with it its due proportion of those impurities. In round figures, with a boiler concentration of, say, 300 grains per gallon, and an average moisture content in the steam leaving the boiler nozzle of 1 per cent, each pound of steam carries with it 0.37 grain of impurities. With these same figures in a boiler plant evaporating 360,000 lb. per hour nearly seven tons of dirt will be carried over each month into the steam-using apparatus at a speed of a mile or two a minute. If there are superheaters, the moisture carrying this dirt is evaporated, and the seven tons of abrasive goes through every valve, governor, engine or turbine as a hot dry sand-blast. None of this may deposit in the steam system, or if any does deposit, it is only a minute fraction of the total amount. The great proportion sweeps through the entire system, doing its "dirty work" all the way from the boilers to the condensers, and disappears with the engine and turbine exhaust. The higher the velocity the less the deposit but the greater the damage, so don't let lack of clogging evidence blind you to the fact that these impurities are sweeping through the steam system.

The average boiler evaporates, roughly, forty or fifty boilerfuls of water every twenty-four hours.[1] Neglecting momentarily the blow-down and the impurities carried out with the steam, as these points will be discussed later, it is easily seen that with the feed water containing only ten grains of soluble salts per gallon, at the end of the first day the boiler concentration would be raised to 400 or 500 grains, and in a week, from 2,800 to 3,500 grains per gallon. In addition, the concentration of insoluble material will also rise and, as previously pointed out, this results very quickly in a solution that causes foaming conditions. According to tests made at the Ohio State University, a concentration of any soluble salts above approximately 28 grains per gallon, with even only a trace of finely divided insoluble material, will cause foaming.

Causes of Foaming

Yet even a very high concentration of soluble salts will not produce foaming unless a small amount of insoluble material is present. Conversely, a relatively high concentration of insoluble material will not cause foaming, but upon the addition of even a slight amount of soluble salts, foaming is produced.

Let us take the same condition as previously, that is, with a feed water containing ten grains of impurities per gallon. It is at once apparent that, neglecting leakage, the only way in which those impurities can get out of the boiler is by the actual boiler water leaving through the blowoff and the actual water carried mechanically over into the steam header.

As an example, if the combined water blown out through the blowoff valve and "blown down into the steam header" is 2 per cent, it is apparent that the boiler concentration will rise to fifty times the feed-water concentration, or to 500 grains per gallon, at which point of concentration the 2 per cent boiler water blown down into the steam header and through the blowoff carries the ten grains of impurities with it, which balances the incoming ten grains per gallon with the feed water.

With 1 per cent moisture in the steam and 1 per cent boiler water leaving the blowoff, 50 per cent of all the impurities entering the boiler after the concentration has reached 500 grains per gallon, will be carried over into the steam header, assuming for the moment that the water has the same concentration at both points. Every pound of steam leaving the boiler will carry five eighths of a grain of impurities. With an evaporation of 60,000 lb. per hour, this amounts to slightly over 125 lb. of dirt each day.

The natural mental reaction to this is that we should blow down the boilers proportionately a great deal more; but here, too, it is a question of dealing with ratios rather than amounts. While at first glance it would appear that doubling the blow-down might tremendously reduce the boiler concentration and consequently the impurities with the steam, this is not actually the case. Doubling the blow-down gives us 2 per cent blow-down or a total water leaving the boiler as liquid of 3 per cent. In this case the boiler concentration will rise to 333 grains per gallon, at which point the total 3 per cent water, leaving the boiler as a liquid, carries out the total ten grains per gallon of solids that are in the feed water. The impurities leaving with the steam are one-third of the total instead of one-half, so that by doubling the blow-down we have reduced the amount of impurities in the steam from 50 per cent of the total entering the boiler to only 33⅓ per cent, or by doubling the blow-down have reduced the amount of impurities in the steam from around 125 lb. per day per boiler to 86 lb. per day.

Reducing Moisture Less Effective than Would Be Expected

Also, it is seen that reducing the moisture content of the steam is in the same wise very ineffective as regards reducing the amount of mechanical carry-over of entrained solids. Offhand, it would appear that if we could, by lowering the water level or by some other means, cut the moisture content from say 1 per cent down to one-half per cent, the amount of impurities carried out with the steam would also be cut 50 per cent, but this is not the case. Reducing the moisture content increases the boiler concentration in this case to 666 grains per gallon, so that the amount of impurities which that smaller percentage of moisture carries is proportionately increased. Conversely, an increase in the moisture content by no means proportionately increases the amount of impurities in the steam. The only real solution is the *complete* elimination of all moisture from the steam before it leaves the boiler drum.

Furthermore, the waste occasioned by increasing the blow-down is too serious to be lightly countenanced. A report on this question by the steam-engineering department of one of the large steel corporation plants recently stated that if the blow-down could be reduced to one-half, the saving in heat loss would amount to $10 per day per boiler. Operating six boilers, the savings would be about $18,000 a year.

Instead, therefore, of hastily taking steps to see that boilers are blown down oftener and more water blown out at each period, it would certainly appear far wiser to devote one's attention towards *reducing* the blow-down.

It is now realized that water in the steam itself is not what causes most troubles, but instead it is what that water carries with it. Complete elimination of the water before the steam

*Abstract of paper delivered at the fall meeting of the Northeast Section of the N.E.L.A., held at Philo, Ohio, on Nov. 13.

[1]While this rate seems high for the average boiler, the general conclusions are not affected.—Editor.

leaves the boiler does away with the greatest proportion of the wearing and erosion, because the impurities which that water contained have been eliminated.

Impurities carried over with the steam cause troubles and danger and expense all the way from the boiler outlet itself clear down to the condenser. Non-return valves are cut, jammed and made inoperative; superheaters are scaled and lose their efficiency and sometimes plug up and burn out; header valves are cut out more rapidly and jammed; meters and gages are often rendered inaccurate, and even inoperative. Automatic engine stops and other safety devices are often put out of commission. Turbines have their nozzles and blading clogged; inlet screens often clog, resulting in decreased pressure and capacity, and at times explosion of the screen. In addition to eroded nozzles and blading, engine valves are cut so as to leak quickly and excessively, and pistons and cylinders are scored and worn; cylinder lubrication is often three and four times as great as necessary, purely because of the impurities in the steam to the engine. Cylinder packing and piston rods are worn and scored, resulting in leaking and rapid replacement necessities. Condenser tubes become fouled or coated with a film of scale, resulting in a loss of efficiency. Scores of instances might be cited, but they are familiar to you.

Analysis of Suggested Remedies

But, you may say, we are going to prevent such results by keeping the boiler concentration so low that it cannot be a problem, and also by making our boilers deliver such dry steam that even with a high boiler-water concentration practically no impurities can be carried over.

Attempts to keep concentration low by excessive blowdown are extravagant and of little avail. While correct feed-water treatment may thoroughly accomplish its objects, the feed water may contain in many cases more soluble salts than the raw water held originally. These soluble salts concentrate very rapidly in the boiler.

Hence, while the feed-water treating system may be the best, and operated perfectly, that alone cannot prevent rapid increases in boiler concentration.

Where conditions make their use practical, evaporators naturally go a long way toward keeping down the concentration of impurities in the boilers. But they cannot by any means accomplish everything. There is a mechanical carry-over of water with the steam from evaporators, just as there is from boilers. It is not possible, even with evaporators, to eliminate entirely foreign matter from the boiler. And it should be remembered that, where evaporators are used, the water and steam system is practically a closed system; that is, except for absolutely unavoidable leaks and (proportionately speaking) extremely small boiler blowdown, there is no chance for the escape of impurities from the system. And because it is a closed system, there are other ways in which impurities are continually entering and increasing the boiler concentration. One of these is, of course, the continual physical disintegration of metals, extremely small it is true, but over a period of time sufficiently large to cause an appreciable increase in the concentration of impurities. Then, too, one must not lose sight of the fact that the evaporator makeup is not necessarily the only makeup of water. A plant may have only 3 or 4 per cent total evaporator makeup, but owing to water-gland and condenser-tube leakage, another 3 or 4 per cent may easily enter the system, and this unmeasured makeup is unfortunately raw untreated water, with perhaps a high percentage of total solids.

Necessity of Purification

The other desired solution to prevent impurities from the concentrated boiler water being carried over with the steam was given as that of trying to make the boilers deliver dry steam. The degree to which steam leaving a boiler will be wet, depends somewhat upon the design and construction of the boiler itself. But so far as the generation of absolutely dry steam is concerned, that is an impossibility, even under research laboratory conditions. As has been pointed out the mere reduction of the percentage of moisture in no wise reduces proportionately the amount of impurities in the steam.

As defined at the outset of this paper, a discussion of the "Physical Side of Concentration in Boilers" is really a discussion of the *results* of such concentration. It has been pointed out that boiler-water concentration cannot be prevented. Neither can boilers be made to generate steam without tending to carry some actual water and impurities with the steam. The *result* of boiler concentration is therefore the production of impure steam, with attendant danger, trouble and expense throughout the entire power plant. Consequently, more attention should be paid to dealing with this result. In other words, since steam cannot be generated that is pure, steps should be taken for the complete removal, mechanically or otherwise, of the impurities from the steam.

Present-Day Piping Problems

At a meeting Nov. 12, 1924, of the Metropolitan Section of the A.S.M.E., a paper by N. C. Nicol, field engineer, Metallurgical Department of the National Tube Co., described the various grades and characteristics of station piping. For high temperatures it appeared that phosphorus as an ingredient was possibly more favorable than generally supposed. Open hearth steel appears to be benefited thereby.

Thus lap-welded steel pipe for boiler plants is now made (under the A.S.M.E. specifications) of soft open-hearth steel having an average ultimate strength of about 50,000 lb. per sq.in. at normal temperature. The average ultimate strength of the same grade of steel to which ferro-phosphorus has been added, increasing the phosphorus content to 0.10, is about 61,000 lb. per sq.in. The latter also seems to hold a somewhat larger proportion of its original strength at the higher temperatures without loss of resistance to impact

The average tensile strength of these pipe steels at 1,000 deg. F. as determined from test, are about, regular open-hearth steel, 26,500 lb. per sq.in., and the same open-hearth steel if rephosphorized, 36,000 lb. This represents a gain of nearly 40 per cent. The A.S.T.M. specification (A-53-24) and the A.S.M.E. specification for lap-welded open-hearth steel pipe limit the phosphorus to not over 0.06 per cent.

By rephosphorizing open-hearth steel to about 0.08 per cent, it can be made of the same approximate strength as bessemer steel and still retain the advantages of open-hearth steel in other respects. Further tests will be made on this steel to determine whether phosphorus is detrimental, as generally assumed, and if not, a change in reference to revising the American Standard specification should be considered.

The importance of flexibility in piping was emphasized by Webster Tallmadge, consulting engineer, New York. The supports should be flexible and anchors or rigid supports eliminated as far as possible. A "floating" piping system is desired. Long hanger rods should be used when piping is suspended.

Spring supports are meeting with favor, especially in supporting drop pipe legs to prime movers or small turbines. For illustration, the piping is set up cold and a condenser drive turbine connected up and coupling aligned. When the steam is turned on, the vertical pipe leg heats up, lifting itself off the upper hanger, imposing all the weight of the pipe on the turbine instead of the support.

The turbine castings are frail and easily pushed out of shape. This is especially true with geared turbine auxiliaries in that the turbines are smaller, owing to the higher speed, yet the pipes are proportionately larger, causing serious misalignment and wear of the high-speed shaft couplings.

The spring hanger properly placed at the top and having a long spring with compression of at least three times the expansion movement would correct this trouble.

Rolls in support are not satisfactory. They stick from corrosion or get dirty.

Bends have been used in place of fittings to absorb movement, but in some cases to excess. The fact is that a tangent or straight pipe is more flexible than a bend, especially in torsion.

The practice of making the piping lengths short by amounts equal to 75 per cent of the expansion is excellent, as the stress is present only when cold and disappears when the line is heated and under pressure.

In general, the main trouble with valves is that they leak. This is due primarily to three things:

First: They are often opened under pressure, straining or scraping grooves in the seats. The function of the by-pass is to equalize this pressure both sides of the valves before opening.

Second: There are usually dissimilar metals in the seats, which expand differently, and for this reason they become loose, or are made with so many parts that they are weak and do not keep their shape.

Third: When a casting is made, it first becomes solid on the exterior, shrinking on the molten or plastic in-

terior imposing strains that are released when reheated. Castings must, therefore, be annealed before being made into valves, or the strain will be released in service and effect a distortion that causes leaking.

Gate valves are commonly used, as they offer clear straight passages. Globe valves obstruct or dam up the condensate so that a pipe may be half full and an ideal condition for water hammer.

The draining of steam piping must not be overlooked, as the most disastrous ruptures are due to accumulated condensate and resultant water hammer. The most serious trouble is probably dirt in the drains, which is encountered in some plants. Steam traps are not what we would like to see them, and the fact that the Holly System is being used in some of the new large stations is interesting.

With regard to the discussion which followed, as briefly reported on page 827 of the Nov. 18, 1924, issue, it may be added that the flexibility, although especially necessary with modern steam conditions, should nevertheless be used with caution. A certain amount of pipe anchorage would control the direction and amount of expansive movement. Rigid points near a prime mover may be an advantage, as preventing thrust due to header displacement.

Welded joints are considered by some to be entirely feasible, but lack trial by actual operation and suitable test for determining their reliability.

Denver Municipal Water Works

Canvass of Bids Opened November 20, 1924

1—15 M.G.D. Steam-Turbine Driven Centrifugal Pump for Capitol Hill Station.
1—10 M.G.D. Motor-Driven Centrifugal Pump for Ashland Ave. Station.

BIDDER	De Laval S. T. Co. "A"		De Laval S. T. Co. "B"			Allis-Chalmers Mfg. Co.		Le Courtenay Co.		M. J. O'Fallon Supt. Co. (Am. Well Wks.)
ITEMS	Capitol Hill	Ashland Ave.	Capitol Hill	Ashland Ave.	Ashland Ave.	Capitol Hill	Ashland Ave.	Capitol Hill	Ashland Ave.	Ashland Ave.
Complete unit with factory test	$29,240.00	G.E. 6,950.00	28,820.00	G.E. 6,950.00	Westhse. 7,940.00		8,475.00			6,568.00
Complete unit without factory test						35,750.00		20,238.00	6,355.00	
G.E. flow meter with recorder	763.00	614.00	763.00	614.00						
Duty per Million B.t.u. in ft.-lb.	103,000,000		107,770,000			110,000,000		99,400,000		
Duty per kw-hr. in ft.-lb.		2,030,000		2,030,000			2,000,000		2,170,000	
Rankine cycle eff. of turbine per cent.	57		59.4			65.0		55.4		
Eff. of motor per cent.							97		92	93.5
Over-all eff. per cent.	47.4	76.6	49.3	76.6	76.2		75.42	54.1	76.5	74.8

DATA OF PUMPING EQUIPMENT

Centrifugal pump:										
Make	De Laval	De Laval	De Laval	De Laval		Allis-Chalmers		Le Courtenay		Am. Well Wks.
R.p.m. (normal load)	900	1,200	1,070	1,200		1,000	1,200	1,100	1,180	1,200
Dia. impeller ins.	28¾	22	24¾	22		24¾	20¼	24	21	20
Peripheral speed of impeller, ft. p.s.	112.6	57.5	113.4	57.6		108	107	115.1	108.2	100
Dia. suction and discharge, in.	18	16	18	16		16	14	20	16	15
Weight pump, lbs.	5,000	3,600	5,000	3,600		6,400	4,900	6,000	4,000	4,500
Reduction Gears:										
Make	De Laval		De Laval			Falk		Terry		
Type	Inv. 8-pitch		Inv. 8-pitch			Dbl. Hel. 6-pitch		Stub 6/8		
Gear ratio: one to	5.61		5.61			3.93		4.28		
Net weight gears, lb.	5,000		5,000			5,700		2,500		
Steam turbine:										
Make	De Laval		De Laval			Allis-Chalmers		Terry		
Stages	—9		—9			3-12 exp.		—11		
B.hp. normal rating	525		525			550		524		
R.p.m.	5,000		6,000			3,900		4,710		
Net wt., lb.	8,000		7,000			13,000		4,800		
Condenser:										
Make	C.H. Wheeler		C.H. Wheeler			Allis-Chalmers		C.H. Wheeler		
Sq.ft. cooling sur.	835		835			886		1,000		
Weight, lb.	11,300		11,300			12,500		18,500		
Air pump:										
Type	Rotex		Rotex			Steam Jet		Rotex		
Make	C.H. Wheeler		C.W. Wheeler			Croll-Reynolds		C.H. Wheeler		
Condensate pump:										
Type	Rotary Gear		Rotary Gear			Cent. Hyd. Turb. Driven		C.H. Wheeler		
Make	C.H. Wheeler		C.H. Wheeler			Allis-Ch.				
Capacity in g.p.m.	30		30			20		35		
Oiling system:										
Type	Grav. Pres.		Grav. Pres.			self-contained		Grav.		
Make	De Laval		De Laval			Allis-Ch.		Richardson-Phenix		
Motor:										
Make		G.E. or West.		G.E.	Westhse.		Allis-Ch.		G.E.	Westhse.
Hp. rated				400	400		400		400	400
Volts				4,000	4,000		4,600		4,000	4,000
Phases				3	3		3		3	3
R.p.m.				1,200	1,230		1,230		1,180	1,200

Engineers Report on Chicago Drainage Canal Diversion

Board of 28 Engineers Makes Statement of Conclusions on Effect on Lake Levels, Water Power and Navigation

ON SEPTEMBER 23, 1924, the Board of Trustees of the Sanitary District of Chicago asked 28 eminent engineers to study the history and the program of the district and to report on the justification of both and their relation to the problems of the Great Lakes. This board is officially known as "The Engineering Board of Review of the Sanitary District of Chicago on the Lake Lowering Controversy and Program of Remedial Measures."

The report states in part:

"The Chicago diversion has lowered the Great Lakes about 5 in., while diversions elsewhere, improvements of outlet channels, and climatic conditions, have caused a lowering of 2 to 3 ft. Reduced lake levels have damaged navigation and harbor works.

"Lake fluctuations can be largely eliminated, and the lakes held near the highest desirable levels, by works constructed near their outlets.

"Diversion of water at Chicago is necessary for sewage disposal; it prevents gross pollution of the lake; it improves navigation in the waterways from the Great Lakes down the Illinois and Mississippi Valleys; and it makes available hydro-electric energy in a region where needed. With lake and river regulation it will confer these benefits without damage to navigation in the Great Lakes and connecting waters; without affecting navigation conditions in the St. Lawrence River; and for years without reduction of power at Niagara and along the St. Lawrence River."

It is estimated that the program recommended by the engineers will involve an expenditure of about $125,000,000.

Water Power

On water power the report states: "The water diverted from Lake Michigan, formerly wasted through the control works at the outlet of the Main Drainage Canal at Lockport, is now utilized to develop hydro-electric power, and the surplus power not required for the works of the Sanitary District is sold to the City of Chicago and other cities in the district for municipal lighting and pumping, and to industries. When the sewage treatment works, now building and planned, are completed, this entire power development will be insufficient to meet the operating requirements of the Sanitary District.

"Full utilization of the water in the Main Drainage Canal and the Des Plaines-Illinois River for the development of power is desirable.

"By reason of the demand for power and its higher market value, a cubic foot of lake water is now worth as much for power production in Illinois as at Niagara, even were the full available head between Lakes Erie and Ontario utilized. There is no economic loss to the country at large by using lake water for power in Illinois instead of at Niagara.

Present Treaty Restrictions

"Furthermore, under present treaty restrictions, the water diverted at Chicago does not now and will not prevent the development of all the water power which it is possible to develop at Niagara by diversions now allowed by treaty.

"On the Upper Illinois River the natural low water flow is approximately 500 sec.ft. Any additional water diverted by the Drainage Canal from Lake Michigan would meet a future demand for condensing water in steam power plants located near the coal mines of the Illinois valley, and would thereby facilitate the production of power by such plants.

"Any water diverted from Lake Michigan reduces the flow of the Niagara and St. Lawrence Rivers and the power that might ultimately be developed on these rivers; at present not quite two-thirds of the power available under treaty restriction is utilized at Niagara.

"The regulating works for increasing and regulating lake levels can be used also for equalizing lake discharges, thereby increasing their present minimum outflows. This would largely increase the prime or continuous power which could ultimately be developed in the Niagara and St. Lawrence Rivers, but such further power development at Niagara would necessitate a modification of the present treaty.

"There are no treaty restrictions as to the use of the St. Lawrence water for power, but less than 10 per cent of the available power is utilized. There will be no economic loss of power on either the Niagara or St. Lawrence River by reason of the diversion of water from Lake Michigan until 95 per cent of the available power at each location is developed."

Power Project Applications on St. Lawrence Denied

The outgoing Democratic New York State Water Power Commission, at its final meeting at Albany on Dec. 29 denied applications for the development of approximately 1,000,000 hp. in the St. Lawrence River, by the Louisville Power Corp., and the St. Lawrence Transmission Co. The Commission at a previous meeting in September denied all pending applications for development of power by private corporations, with the exception of these two companies.

Junior Engineers Wanted by Government

The United States Civil Service Commission announces an examination for a junior engineer on Jan. 21. It is to fill vacancies in various branches of the government service at entrance salaries of $1,860 with advancement up to $2,400.

Examinations will be given in the following optional subjects: Aeronautical, bridge, chemical, civil, electrical, explosives, highway, hydraulic, mechanical (fuel combustion), mining, petroleum, radio and structural engineering.

Competitors will be rated on general physics, pure mathematics, practical questions on the optional subjects chosen and education, training and experience. Full information and application blanks may be obtained from the United States Civil Service Commission at Washington, or at the post office or custom house in any city.

Hetch Hetchy Power Ready in Spring

After a three weeks' shutdown on certain phases of the construction work on the Hetch Hetchy municipal water and power project of the City of San Francisco, due to the depletion of the 1910 forty-five million dollar bond issue, work is again to be resumed.

After failure to transfer these funds or to find some other means of financing the continuation of the work, the Spring Valley Water Co., a private utility supplying water to San Francisco, offered to advance $1,000,000 in cash, as advance rental due the city under a contract privileging the water company to use the city's aqueduct across San Francisco Bay.

This offer was accepted and work was ordered resumed on Dec. 22. The stop order did not affect work on the Moccasin Creek power house nor work on the transmission line, but did delay work on the lining of the tunnel and at the intake. The power end of the project is scheduled for completion early in the spring of 1925.

General Electric Disposes of Electric Bond & Share Co.

The General Electric Co., according to press reports, after a meeting of the directors on Dec. 30 announced that it would dispose of all of its shareholdings in the Electric Bond & Share Co., a subsidiary holding company for public-utilities financing, by organizing a new corporation. The new corporation, in consideration of such transfer, will distribute its shares to the stockholders of record of the General Electric Co., the distribution to be made as of Jan. 15, 1925.

When asked if the proposed investigation at Washington had anything to do with the segregation announced, President Gerard Swope said that the question had been under consideration for more than two years. It was announced that the administration of the Electric Bond & Share Co. will continue under the presidency of S. Z. Mitchell.

Colfax Plant of Duquesne Company Completed

The third and last 30,000-kw. turbogenerator to be installed at the Colfax plant of the Duquesne Light Co. at Pittsburgh will go on the lines soon. With the 60,000-kw. machine that preceded these units, this will bring the total rating of Colfax to 150,000 kw., its full capacity.

Very soon ground will be broken at Shippingport, in Beaver County, on the Ohio River, for the company's new power house, to be known as the Beaver station. It will have an ultimate capacity of 375,000 kw. and will cost around $30,000,000. This station, Colfax and Brunot Island would form the points of a triangle that might be drawn within the 66,000-volt transmission ring surrounding industrial Pittsburgh.

Advocates Investigation of Power Trust

A resolution proposing that the Federal Trade Commission investigate and report to the Senate the extent to which a power trust exists in the United States was introduced Dec. 29 by Senator Norris of Nebraska. On the objection of Senator Edge of New Jersey, immediate consideration of the resolution was blocked, and as this is written, no action on it has been taken by the Senate.

In the discussion of the so-called power trust Senator Norris was asked if there are in the country any electric utilities that are not controlled by the General Electric Co. The Senator replied that he know of none. It is generally recognized however, that the General Electric has no interest in such outstanding enterprises as the New York Edison Co., the Commonwealth Edison Co. of Chicago, the Pacific Gas & Electric Co., the Southern California Edison Co. (which has greater interests in hydro power than all other companies put together), all of the properties of the H. M. Byllesby Co., all of the properties of Henry L. Doherty, and the City Service Co., all of the properties of Stone & Webster. The list could be prolonged considerably.

San Antonio Plant Being Planned

Preliminary plans for a steam-electric power plant on the Guadalupe River near New Braunfels, Tex., for the purpose of supplying San Antonio with cheaper electric power have been completed, according to announcement by W. B. Tuttle, vice-president San Antonio Public Service Co.

The proposed plant will be built and operated by the Comal Power Co., a subsidiary of the San Antonio company, which has made application to the State Board of Water Engineers to use the water of the river for condensing purposes. Actual construction will not start for some time, Mr. Tuttle says, but a site has been selected.

Engineering Foundation To Push Research

The appointment of 190 leading engineers in twenty-seven cities as local representatives of the Engineering Foundation, with national headquarters at 29 West Thirty-ninth Street, was announced recently by F. Rand, chairman, 71 Broadway, New York City. These engineers, representing industry, education and the public service, will help the Foundation Board in a nation-wide plan "for the furtherance of research in science and in engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind."

The Foundation's work will be carried on with the $500,000 endowment provided by Ambrose Swasey of Cleveland, Ohio, reinforced by a recent bequest of $50,000 from the estate of Henry R. Towne. A group of prominent engineers in New York and other centers is charged with the immediate direction of the Foundation's affairs.

Besides the Foundation's appropriations to aid research, contributions from industries and other sources aggregate more than $100,000.

North American Co. Plans Huge Expenditures

The North American Co., according to an announcement by President F. L. Dame, recently in the press, plans to expend $41,500,000 during 1925 for new construction work and other developments of the physical properties of the company's subsidiaries which furnish utility service to localities around Cleveland, St. Louis and Milwaukee.

Plans for the northern Ohio district surrounding Cleveland call for an expenditure of about $20,000,000 in 1925. In the Illinois-Missouri territory centering in St. Louis, the expenditures for additions and extensions will aggregate about $11,000,000, and for the Wisconsin and Michigan sections expenditures of $10,000,000 will be made. Electric and coal properties in Kentucky will be improved at a cost of $500,000.

President Dame, in outlining the plans, said that the largest single piece of expansion would be the new 400,000-hp. station at Avon, Ohio, near Cleveland, described in the Nov. 25 issue of *Power*, page 864. A new station for supplying steam heat will be constructed in Cleveland, and other important extensions will be made to the company's distributive lines.

Interchange of Power With Staten Island Desired

The New York-New Jersey Superpower Connecting Corp. of New Jersey, has made application to the New York State Public Service Commission for consent to acquire and hold stock of the Staten Island Edison Corp.

The petition states that the superpower corporation proposes to contract with the Staten Island Corp. for the interchange of power, and that the full development of the plan, because of the large sums involved, makes desirable a mutuality of ownership as well as of interest.

Since the formation two years ago of the Staten Island Edison Corp., as a reorganization of the Richmond Light & Railroad Co., the electrical output has increased from 36,592,800 kw.-hr. to 57,023,400 kw.-hr. per year, an increase of 56 per cent, it is claimed. The company has contracted to furnish the Staten Island Rapid Transit Railway with 17,000,000 kw.-hr. annually with the completion of its electrification. This will increase the corporation's load, the petition states, to a point where it will be necessary to find other sources of power. The petition sets forth that the most likely sources are in New Jersey, and to the west where there are in service or construction large central station plants at tidewater.

Dr. Durand Advocates Boulder Dam Development

At the hearings on the Swing-Johnson bill, designed to develop power at Boulder Dam on the Colorado River, which have been held recently by the Senate Irrigation and Reclamation Committee, the importance of the hydro-electric power which would be developed at the dam in conserving the Nation's oil supply was emphasized as one of the strongest arguments in favor of the measure, according to press reports. Speaking on this phase of the project, Dr. William F. Durand, of Stanford University, and president of the A. S. M. E., told the committee:

"From the viewpoint of national conservation of oil resources it is most important that the Boulder Dam project be put through. It has been estimated by the Geological Survey that our present oil supply will be exhausted within a quarter of a century. It is important to develop all sources of hydro-electric power to conserve oil for other uses for which there is no substitute." Doctor Durand estimated that the demand for power in the whole Southwestern territory to be served by the project would amount to 1,800,000 hp. in 1935 and over 2,500,000 hp. by 1940. "There is an assured market for all the power to be developed at Boulder Dam," he asserted.

Other Los Angeles advocates for the development of Boulder Dam said that 570,000 hp. will be required by that city alone in 1930 and that a large part of this will have to be obtained from some new source.

Giant Power Survey Advisory Committee Urges State Co-operation

Committee Suggests Keeping Broad Objective in Regard to Electrical Development Prominently Before the People

GENERAL WILLIAM CROZIER, chairman of the Advisory Committee of the "Giant Power Survey" of the State of Pennsylvania, in a letter to Governor Gifford Pinchot, under date of Dec. 15, 1924, makes comments and suggestions with reference to the forthcoming report of the Giant Power Survey Board. The letter in part says:

"Your Committee, appointed to advise you in regard to the work of the Giant Power Survey authorized by act of the Pennsylvania Legislature, has met in New York City and has listened to an explanation of the Giant Power program by the director of the survey, Morris L. Cooke.

"At the outset it can be stated that the Advisory Committee is strongly of the opinion that there should be a program, which should cover, as well as the present state of knowledge permits, the development of the electrical industry. This industry now supplies a public necessity comparable with the need for transportation, for water supply, or for any other fundamental requirement of civilization; and the committee believes that the Legislation of Pennsylvania has performed a distinct public service in providing for an inquiry which may lead to the establishment of such a program.

"We think that this inquiry presents two aspects which are of general interest and outstanding importance. The first is the relation of the project initiated by the State of Pennsylvania to the nation as a whole, and especially to the neighboring states. The second is its relation to the enormous and rapidly developing electrical industry of the country.

Great Development Expected

"In the first place, your committee believes that in this country we are on the threshold of a development in the use of electric power which is comparable only to the development of steam power during the Nineteenth Century. This development is being made feasible by the possibility of transmission of electric current over long distances, not only into the factory and workshop, but into the home and onto the farm. In providing for a survey of the future of this development upon lines which shall be farsighted, economical and in the public interest, the State of Pennsylvania is taking a step which is not only of interest to the rest of the country, but which can attain the fullest success only by the co-operation of the whole nation. We think that it is of the highest importance that this development should proceed without the economic waste, the rivalry between different jurisdictions, and the acrimony between private industry and the public, which formerly characterized a similar development in the case of our railroads.

"It is manifest that this cannot be done unless there is, so far as possible, harmony of purpose and of method throughout the country. On the other hand, it is equally manifest that to throw upon the national government the burden of regulating the details of such a development, in addition to the other activities already exercised by it, would involve overcentralization and evils of bureaucratic control which should be avoided if another solution can be found. Unlike the situation which existed at the time when our railroad development was beginning, most of the states now have systems of public service commissions and other agencies for exercising the necessary control over public utilities, and your committee believes that a solution by co-ordination of the already existing state agencies, if possible, would be preferable to centralized federal regulation.

"For this reason, we think that such a project as that which Pennsylvania has embarked upon should meet with the approval and co-operation of every far-sighted citizen, and particularly of those entrusted with the management of the affairs of its neighboring commonwealths. The economic possibilities of electrical development are not confined within the artificial boundaries of the states, and it is only by co-operation that harmonious regulation can be instituted and consequently full development be attained.

"The first step toward ascertaining whether the co-operation is possible is for some commonwealth like Pennsylvania to undertake to make such a survey and plan as has now been authorized and is being formulated.

"In the second place, we have witnessed since the war a marked development on the part of the electrical industry itself in the direction of obtaining economies of operation and completeness of service by interconnection between different systems. More and more the leaders of the industry are recognizing the problem which is upon us, and are seeking, by foresight within the industry, to secure those advantages which accompany the covering of a considerable territory with a system which enables all parts of the territory to pool the resources to be found within its boundaries.

"Natural growth under this leadership would probably in the end bring about a unification of plan and an eventual utilization of the best method of generating, transmitting and distributing electric current; but this result would be attained only at the cost, on the way, of many installations of an unsatisfactory character and size which might have been avoided could the broad lines of the final development have been considered and insisted upon from the beginning.

"We think that it is a proper function of the state to provide such a comprehensive view of the problem and to insist that expenditures should, so far as possible, conform to an ultimately complete general plan rather than merely to meet the immediate exigencies of corporations serving restricted localities.

"The state cannot command any greater expert knowledge than is employed by the industry, but it can supply a broader view and the power to insist upon the adoption of the ultimate, rather than the immediate, objective. We think that this leadership of the state, however, should be exercised only with the fullest recognition of the progressive tendencies on the part of industry itself, which differentiate the present situation in the electrical world from a corresponding stage in the evolution of many other services. We see no reason why anything but the fullest and most sympathetic co-operation between the state and the industry should exist, and we believe that the public interest requires such co-operation.

"Your committee believes, therefore, that the beginning which is being made by the State of Pennsylvania should be followed up, and that the good start which has been had in the effort to guide properly and with forethought this great development should be pursued in such manner as to keep the subject prominently before the people of the state and of the nation."

New Power Station Being Built at Des Moines

A new power station, to be known as the Ball Ford power station, is being built by the Iowa Power & Light Co., a subsidiary of the Des Moines Electric Light Co., below the junction of the Des Moines and Raccoon Rivers near the City of Des Moines. The initial capacity of the station will be 60,000 kva., the two units now being constructed being rated at 25,000 kva. and 35,000 kva. respectively. The ultimate capacity is planned for 165,000 kva., and as needed, additional units will be installed. Steam will be generated at 375 lb. pressure with a total temperature of 680 deg. F. Subaqueous coal storage of 50,000 tons is provided with plans for the expansion of the pit to a capacity of 150,000 tons. The annual fuel requirements of the station as now being built will be 200,000 tons. When completed to its full capacity, these requirements will reach 650,000 tons annually.

Obituary

Chas. A. Allen for the past thirty years New York manager for the American Steam-Gauge and Valve Mfg. Co. passed away at his home in Brooklyn on Dec. 24. He was born in Brooklyn 69 years ago and in his earlier business career was connected with the Rumsey & Co. and Silsby Fire Engine Co. His many friends in the machinery and supply field will feel this absence deeply.

Society Affairs

The Detroit Engineering Society will hear W. A. Carter, of the Detroit Edison Co., speak on "Firebrick," at its Jan. 16 meeting.

The Detroit Section of the A.I.E.E. will hold a meeting on Jan. 13. C. Lichtenberg, of the General Electric Co., and J. W. Bishop, of the Detroit Edison Co., will speak on "Automatic Substations."

The New England Water Works Association will have as the attraction for its Feb. 10 meeting, "A Symposium on Diesel Engines," with the principal paper by C. B. Jahnke, chief engineer of the Fairbanks-Morse Co.

Personal Mention

John Hunter has recently established his office at 805 Merchants-Lacede Bldg., St. Louis, Mo., for consulting and advisory engineering service. This will include investigations of industrial and power problems in design, construction and operation leading to decrease in cost of installation and increase in efficiency.

Vernon G. Leach on Jan. 1 severed his connections with the Bell & Zoller Co., as combustion engineer and fuel expert, to accept a position in the same capacity with the Nason Coal Co., 37 West Van Buren St., Chicago, Ill. It may be recalled that this company is developing the largest mine in the world which eventually will develop a daily hoist of 16,000 tons. Mr. Leach, who is a member of the A.S.M.E., is the patentee of powdered-coal burning equipment and has developed the Ellison-Leach gas analyzer.

Harold V. Bozell, for the past two and a half years editor of *Electrical World* jointly with W. H. Onken, Jr., has resigned, effective Jan. 1, to join Bonbright & Co., Inc., investment bankers dealing in bonds and preferred stocks of electric light and power companies. Mr. Bozell's work will be largely advisory, covering utility operations and technical matters, and his appointment represents an expansion of Bonbright & Co. in the direction of maintaining more intimate contact with the light and power industry.

Business Notes

The Williams Gauge Co. announces the removal of its offices on Jan. 1, to 1620 Pennsylvania Ave., N. S., Pittsburgh, Pa.

The New York Edison Co.'s general offices, will after Jan. 1, be located in the fourteenth, fifteenth, sixteenth and eighteenth floors of the new Equitable Life Assurance Society Building, 393 Seventh Ave., New York City.

The Liptak Fire-Brick Arch Co., 20th St. and Prairie Ave., Chicago, Ill., is going to move its main office from Chicago to Mexico, Mo., on Jan. 1. A sales office will be continued at the Chicago address, and the New York office, 50 Church St., will also be continued.

Coming Conventions

American Boiler Manufacturers Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Midwinter meeting at Cleveland on Feb. 12.

American Ceramic Society. R. C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Columbus, Ohio, Feb. 16-21.

American Engineering Council. L. W. Wallace, 24 Jackson Place, Washington, D. C. Annual meeting at Washington, D. C., Jan. 16-17.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at New York City, Feb. 9-13.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 16-19.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 22-26.

American Society of Heating and Ventilating Engineers. F. C. Houghten, 33 West 29th St., New York City. Annual meeting at Boston, Jan. 28-30.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Milwaukee, Wis., May 18-21.

Canadian Association of Stationary Engineers. Geo. J. Soucy, 48 Moore Ave., Toronto, Ont., Secy. Convention at Windsor, R. M. McLaren, 160 Doorcourt Rd., Toronto, Ont., June 29-July 1.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Que. Annual meeting at Montreal, Que., Jan. 27-29.

Exposition of Inventions—American Institute, E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Bldg., 29 West 39th New York City, April 27 to May 2, formerly announced for Dec. 8-13.

Illinois Society of Engineers. E. R. Tratman, Wheaton, Ill. Meeting at Chicago, Jan. 14-16.

Iowa Engineering Society. J. S. Dodds, Box 202, Ames, Iowa. Convention at Des Moines, Iowa, Jan. 27-30.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Pennsylvania Association** at Pittsburgh, Pa., May 15-16. Frank J. McCarron, 3647 North 11th St., Philadelphia, Pa. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **New England States Association** at Worcester, Mass., June 18-20. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

National Marine Engineers Beneficial Association. Geo. A. Grubb, 313 Machinists Building, Washington, D. C. Convention at Hotel Franklin Sq., Washington, D. C., Jan. 19.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, National convention at Hotel Winton, Cleveland, Ohio, May 6-8.

Western Association of Electrical Inspectors. G. M. Miller, 1304 South 7th St., Louisville, Ky. Annual convention at the Brown Hotel, Louisville, Ky., Jan. 27-28.

Trade Catalogs

Blower—B. F. Sturtevant Co., Boston 36, Mass., "Gaso-Fan" a new type of portable blower is described in a leaflet just published.

Coal Meters—Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill. Bulletin CM-27 "Measurements of Coal with Republic Coal Meters," describes this meter for coal, which can be accommodated to any type of chain-grate stoker.

Valves.—Homestead Valve Manufacturing Co., Homestead, Pa. Catalog No. 32 gives complete descriptions of the line of valves manufactured by this company with price and principal dimensions lists. It is well illustrated and contains an index.

Transmission, Power—W. A. Jones Foundry & Machine Co., 51 West Roosevelt Road, Chicago, Ill. Catalog No. 31 describes hangers, couplings, shafting, etc., or the power transmission machinery manufactured by this company. Lists of dimensions and prices are included.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal, Net Tons	Market Quoting	Dec. 22, 1924	Dec. 29, 1924
Pool 1	New York	$2.95	$2.95
Smokeless	Columbus	2.10	2.10
Clearfield	Boston	2.40	2.40
Somerset	Boston	2.50	2.50
Kanawha	Columbus	1.65	1.65
Hocking	Columbus	1.75	1.75
Pittsburgh No. 8	Cleveland	1.90	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.75	1.75
S. E. Ky.	Louisville	1.50	1.50
Big Seam	Birmingham	1.90	1.90

FUEL OIL

New York—Dec. 31, light oil, tank-car lots; 28@34 deg. Baumé, 5c. per gal.; 36@40 deg., 5¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis — Dec. 16, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95 per bbl.; 26@28 deg., $2.00 per bbl.; 28@30 deg., $2.05 per bbl.; 30@32 deg., $2.10 per bbl.; 32@36 deg., gas oil, 5c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Dec. 16, f.o.b. local refinery; 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.

Dallas—Dec. 30, f.o.b. local refinery, 26@30 deg., $1.47 per bbl.

Philadelphia—Dec. 28, 28@30 deg., $2.20½@$2.268 per bbl.; 18@20 deg., $2.047@$2.11; 13@16 deg., $1.89@$1.953 per bbl.

Boston—Dec. 29, tank-car lots, f.o.b.; heavy oil, 12@14 deg., Baumé, 4.45c. per gal.; light oil, 28@32 deg. Baumé, 5½c. per gal.

Cincinnati — Dec. 22, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5¾c. per gal.; 26@30 deg., 5¾c. per gal.; 30@32 deg., 6½c. per gal.

Chicago—Dec. 16, tank-car loads, delivered within city limits, 20@22 deg., 6c. per gal.; 24@26 deg., 6c.; 28@30 deg., 6½c.; 30@32 deg., 6¾c. per gal.

New Plant Construction

Ala., Birmingham—Continental Gin Co., Title Guarantee Bldg., has awarded the contract for the construction of a factory including a 150 x 300 ft. boiler house and dry kiln, etc., to H. K. Ferguson Co., 4900 Euclid Ave., Cleveland, O. Estimated cost including equipment $1,000,000.

Ark., Walnut Ridge — Texas Central Power Co., Frost Bldg., San Antonio, Tex., is receiving bids for the construction of a power and ice plant, estimated cost $60,000. J. Mariott, Frost Bldg., San Antonio, is architect. Owner is in the market for 40 ton ice plant, also engines, equipment, etc., for power plant.

Calif., Butte City — Butte City Ranch plans to irrigate 2,552 acres of land, involving installation of 5 pumping plants, 12 in. centrifugal, with 50 hp. motors, 4 mi. power line, etc. Private plans.

Calif., Long Beach—Peoples Ice and Cold Storage Co. has awarded the contract for the construction of a 2 story, 55 x 110 ft. ice plant on East Anaheim St., to W. J. Burgin, Pacific Southwest Bldg., Los Angeles. $45,000.

Calif., Los Angeles—Globe Ice Cream Co., 230 West Jefferson St., will build a 2 story, 50 x 152 ft. annex to ice plant on Hill and Jefferson Sts., by day labor. Estimated cost $45,000.

Calif., Santa Barbara—Puritan Ice Co., Santa Barbara, is making plans for the construction of a 10 x 100 ft. addition to ice plant, 5,000 ton capacity. Estimated cost 75,000.

Conn., Waterbury — Waterbury-Farrel Fdry. & Machine Co. is in the market for motor generator set 400 to 500 kw. with synchronous motor, 440 or 2200 volt, 3 phase 60-cycle and generator 250-volt, d.c., starting devices and switchboard.

Ga., Davisboro—The Town is planning to construct a municipal light plant, estimated cost 25,000. J. B. McCrary & Co., Bellwood Ave., Atlanta, are engineers.

Ga., Griffin—W. F. Ingram and Associates awarded the contract for the construction of the Highland Mills cotton mill and warehouse, boiler house, etc., to Fiske-Carter Construction Co., Greenville, S. C.

Ill., Great Lakes—Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans improvements to power plant at the Naval Training Station, estimated cost $30,000.

Ind., Anderson—City is in the market for one new 5,000-kw. turbine engine for light plant. Estimated cost. $125,000. M. H. Downey, City Hall, is engineer.

La., Bunkie—E. H. Talifero, Mayor and Board of Aldermen, will receive bids until January 13, for pumping station, 1 75 heavy duty oil engines, 500 g.p.m. fire pump and 1,500 g.p.m. motor driven fire pump.

La., New Orleans—Canal Realty & Impt. Co., 1401 Tulane Ave., has awarded the contract for the construction of a theatre and office building on Canal St., to G. J. Glover Constr. Co., Whitney Central Bank Bldg. Estimated cost $1,000,000. Refrigerating and heating systems will be installed.

La., New Orleans—The Sewerage and Water Bd. at office A. G. Moffat, Secy., 526 Carondelet St., Room 401, will receive bids until February 16, for one 400 g.p.m. boiler feed water pump steam turbine driven complete on base plate, one 200 g.p.m. boiler feed water pump suitable for steam turbine operation, one 2800 g.p.m. centrifugal pump, motor driven, complete on base plant.

Md., Baltimore—M. Stein, Lake Drive, is having plans prepared for the construction of a 9 story, 100 x 100 ft. apartment, estimated cost $500,000. B. F. McGuire, 110 West 34th St., New York, N. Y., is architect.

Mo., Clayton—St. Louis County is having preliminary plans prepared for the construction of a 3 story hospital. Estimated cost $1,000,000. Engineer and architect not announced.

N. Y., New York—New York Central Railroad, Grand Central Terminal, is having plans prepared for the construction of an office building at Lexington Ave. and 43rd St. Estimated cost $10,000,000. Cross & Cross, 385 Madison Ave., are architects.

N. Y., New York—One Thousand One Hundred and Seven 5th Ave. Corp., c/o Rouse & Goldstone, Archts., 512 5th Ave., having plans prepared for construction of 13 story, 108 x 109 ft. apartment, including steam heating system on 5th Ave. and 92nd St. Estimated cost, $1,150,000.

N. Y., Troy — Community Hotel Corp., Troy, is having plans prepared for the construction of a 10 story, 140 x 210 ft. hotel on Bway. Estimated cost $800,000. C. L. Harding, 729 15th St., Washington, D. C., is architect and engineer.

Neb., Omaha—Eppley Hotels Co., Omaha, is having preliminary plans prepared for the construction of a power plant for the Hotel Fontenell, engine, boiler and possibly generator will be required. Cahill & Douglas, 217 West Water St., Milwaukee, Wis., are engineers.

N. C., Franklin—The City will receive bids until Jan. 6 for equipment for municipal light plant, one switchboard, two 750 hp. water turbines, two 750 kva. generators, two 750 kva. transformers. Roberts & Co., Tuft Bldg., Atlanta, Ga., are engineers.

O., Canton—Lyman Rodgers & Co., Clark Bldg., plans the construction of a 14 story 66 x 200 ft. hotel, 3rd and Cleveland Sts. N. W. Estimated cost $2,000,000.

O., Cleveland—W. S. Ferguson & Co., Archts., 1900 Euclid Bldg., soon takes bids for the construction of 10 story 135 x 320 ft. auto sales and office building on Euclid Ave., for the Motors Realty Co., c/o G. G. Peckham, 1903 East 19th St., Pres. Estimated cost $1,500,000.

O., Columbus—Columbus Beveling and Silvering Co., North 3rd St., is in the market for two 85 hp. motors and 150 ft. shafting, etc. E. C. Hill, is purchasing agent.

O., Toledo—Park Apartments, Inc., awarded the contract for the construction of a 9 story, 73 x 156 ft. apartment on Jefferson Ave. to A. Bentley & Sons Co., Belmont Ave. Estimated cost $1,000,000.

Okla., Claremore—City is making preliminary plans to enlarge water supply system including filter plant, pumping equipment, etc., estimated cost $100,000. Engineer not selected.

Ore., Portland—The City is having plans prepared for waterworks for Multnomah Water District, and will probably require 1,000,000 g.p.d. steam driven pumps, estimated cost $100,000. Barr & Cunningham, Spalding Bldg., are engineers.

Tenn., Chattanooga—Read House, S. R. Read, Pres., 9th and Broad Sts., is having plans prepared for the 328 room addition to hotel at 9th and Broad Sts., estimated cost $1,250,000. Holabird & Roche, 1400 Monroe Bldg., Chicago, Ill., are architects.

Tenn., Knoxville — City is having preliminary plans and surveys made of Holston and Tennessee Rivers, for location for new intakes, filters and pumping plants, estimated cost $2,500,000. F. W. Albert is superintendent of waterworks.

Tenn., Memphis—Memphis Power & Light Co., Memphis, has made application for the authority to issue and sell $1,000,000 bonds, the proceeds to be used in plant improvements.

Tenn., Memphis—University of Tennessee, Knoxville, is making plans for the construction of a group of building including a power house. Jones & Furbringer, Porter Bldg., Memphis, are architects.

Tenn., Nashville—City is having plans prepared for the installation of new boiler system, etc., for pumping station. Estimated cost $500,000. H. E. Howse is mayor.

Tenn., Nashville—Independent Order of Odd Fellows, c/o W. N. Hannah, Secy., is having preliminary plans prepared for an 8 story lodge and office building at 119 7th Ave. North. Estimated cost $800,000. Engineer and architect not selected.

Tex., Abilene—Independent Ice & Refrigerating Co., T. T. Harris, Pres., will build a 60 x 140 ft. ice plant on 6th St. Estimated cost $75,000.

Tex., Brownfield—Texas Utilities Corp., W. H. Allen, Mgr., having plans prepared and soon takes bids for the construction of an ice plant. Estimated cost $50,000. Private plans.

Tex., Childress—Texas Central Power Co., Frost Bldg., San Antonio, has awarded the contract for the construction of a 40 x 60 ft., electric and power house, to Sumner-Sollitt Co., San Antonio. Estimated cost $40,000. Owner is in the market for 40-ton capacity ice plant.

Tex., Clifton—E. Handley, Mayor and City Council will receive bids until Jan. 9 at office of W. C. Hurst, City Secy., for one 100 hp. and one 150 hp. oil engine generating units, 2 generating switchboard panels, one distributing panel, etc.

Tex., Corpus Christi—Texas Central Power Co., Frost Bldg., San Antonio, will take bids after Jan. 1, for construction of new boiler house, here. Estimated cost $40.000. Owner is in the market for engine, dynamo, generator, etc.

Tex., Houston—J. M. Glover, Archts., Bankers Mortgage Bldg., and San Jacinto Realty Co., 4401 Montrose Ave., will receive bids until about Jan. 15, for the construction of 2 story apartment on Montrose Blvd. Estimated cost $500,000.

Tex., Houston—J. M. Grover, Houston, is having plans prepared for the construction of a 5 story 125 x 192 ft. apartment. Estimated cost $500,000. G. B. Post & Son, 1003 Pioneer Trust Bldg., Kansas City, Mo., are architects.

Tex., Kingsville—J. M. Glover, Archt., Bankers Mortage Bldg., Houston, will soon take bids for an addition to ice plant, including machinery, for the Kingsville Commercial Co. Estimated cost $42,000.

Tex., San Antonio—San Antonio Turnverein Society, Houston and Nacogdoches Sts., is having plans prepared for the construction of a 10 story 60 x 110 ft. hotel, on Houston and Nacogdoches Sts. Estimated cost $650,000. L. Harrington & Co., Houston Bldg., are engineers and architects.

Tex., Trinidad—Texas Public Utilities Co., Interurban Bldg., Dallas and Southwestern Power & Light Co., 71 Bway., New York, N. Y., are having plans prepared for construction and installation of a 40,000 kw. steam operated plant on Trinity River, ultimate capacity 150,000 kw., will develop adjacent lignite land for fuel supply. Private plans.

Wash., Puget Sound—Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids until January 21, for extension to boiler plant and distributing system here.

Wis., Cedarburg—T. F. Wittenberg and J. F. Nieman, both of Cedarsburg, are forming syndicate which plans to construct 3 story and basement, cold storage plant. Estimated cost $60,000. Engineer and architect not selected. Owner is in the market for refrigeration machinery.

Wis., La Crosse—W. Doerflinger Co., 4th and Main Sts., is making plans for the construction of an oil burning generating plant to generate power, light and heat for owner's department store. Estimated cost, $20,000. Engineer not selected.

Wis., North Milwaukee—Christoffel Concrete Products Co., R. 2, plans to rebuild 2 story 60 x 200 ft. plant, on Cedarburg Rd., recently destroyed by fire. Estimated cost $40,000. Engineer and architect not selected. Owner is in the market for machinery and electric motors.

Wis., West Bend—City plans installation of a new pumping equipment in Hickory St. Pumping station. C. P. Heipp, is city clerk. Engineer not selected.

Panama, Cocosolo—Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans improvements to refrigeration plant, estimated cost $36,000.

T. H., Pearl Harbor—Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans extension of motor generator building and equipment for submarine base, estimated cost $55,000.